SURVIVAL STRATEGIES OF CRABS

Marine biologists are finding out more and more about the behaviour of crabs, and the strategies by which crab populations are maintained.

Weed covered rocky shores, exposed by the ebbing tide, arouse our exploratory instincts, especially in young members of the family. Shrimping nets and buckets often catch animals about which questions are asked, but not always answered. Interest is usually more apparent if the animal is found to be in a particular phase of its life: for example, a crab moulting, or carrying eggs. Our knowledge about marine organisms is considerably greater today than when the eminent Victorian naturalists Philip Henry Gosse and Charles Kingsley first began to popularise the growing science of marine biology. Research has revealed that marine animals adopt various strategies for maintaining their populations, and some of these can be seen in operation, particularly during the reproductive part of their lives.

Protecting the eggs The common shore crab (*Carcinus maenas*) serves to illustrate a number of protective strategies that are commonly adopted in the breeding season of crabs. Females carrying eggs are said to be in berry, and are not uncommon in shore rock pools during summer. The egg mass (spawn or plug) is attached to fine hairs on the female's abdominal limbs, and the abdomen is loosely folded beneath the body shell, partly protecting the eggs. Carrying the eggs instead of shedding them directly into the sea increases their chances of survival until they hatch.

Above: A shore crab brandishes its claws in an aggressive manner. This is an automatic response to perceived danger. By this behaviour the crab confuses or intimidates a predator, gaining time to find a hiding place.

Below: This scorpion spider crab (*Inachus dorsettensis*) is camouflaged with a living coat of sponges on its back and legs. To complete the camouflage, it spends its life on or near the main sponge colony.

Above; Females of many crab species can mate only when their shell is still soft after moulting. The female shore crab is protected while in this vulnerable condition by the male carrying her beneath his body. At first he carries her the right way up, but after moulting she turns her ventral face against the male's, and mating occurs.

Left: A female shore crab carrying its eggs. It is said to be 'in berry'.

Below: The soft mud of upper shore saltmarshes provides a suitable substrate into which shore crabs burrow for protection: two burrows are visible.

Female crabs with eggs can be quite defensive and tend to be more secretive than others. Females of the shore crab move into deeper waters after becoming berried, as do females of the edible crab (*Cancer pagurus*). It has been observed that berried females of the edible crab behave with great caution, and do not enter traps when in this condition.

Spawning and hatching Newly spawned eggs are bright orange, and turn brown to grey progressively as they develop; this may take several months. As hatching time approaches, the female raises her body and preens the eggs frequently with the tips of the walking legs. During hatching, she occasionally waves her abdomen to disperse the emerging larvae. These are minute, equipped with paired swimming limbs, large jaws, well developed eyes and a segmented abdomen bearing a forked tail.

Mortality of crab larvae These shore crab larvae now become members of the vast planktonic community that inhabits the upper layers of coastal waters. During the weeks spent in this region, where they pass through four stages of growth, they are exposed to many predators and mortality rates are very high. Because of this, shore crabs can maintain their populations only by producing vast numbers of eggs–over 185,000 at each brood.

Other crab species also adopt this strategy, varying in the degree of 'overproduction'. In the edible crab, a medium-sized specimen produces well over 2,000,000 eggs at each spawning. At the other extreme, some spider crabs, such as the scorpion spider crab (*Inachus dorsettensis*), produce far fewer eggs –perhaps a few thousand–in each brood, but these hatch in a more advanced state of development. The *Inachus* larvae thus spend less time in the hazardous planktonic region, so that a greater proportion of them survive. Spider crabs of this species are continuously spawning and hatching eggs throughout most of the year, and so ensure that there will be sufficient numbers in future generations to maintain the population.

Dispersing to survive During these planktonic stages, the minute larvae are carried in water currents that disperse them from the hatching grounds. They also respond to changes in light, pressure and temperature by swimming upwards and downwards to various levels, where they may enter the paths of currents flowing in different directions from those at the surface.

The four planktonic stages of the shore crab are all similar and increase in size at each stage; growth is accomplished by moulting. The larvae finally moult into a form having a shape similar to that of the following juvenile crab stage, and settle on the sea-bed. Settled larvae often occur in vast numbers low on the shore, during spring and early summer.

Defence mechanisms of juveniles The young crabs grow quickly, and often have attractive colour patterns that make them less con-

spicuous when matched against backgrounds of weeds, pebbles or shingle, and probably reduce the chance of being spotted by predatory birds. As the crabs further increase in size, this patterned shell colour disappears and protection is then afforded by an increase in body shell thickness and the aptitude to shelter beneath weeds and in crevices.

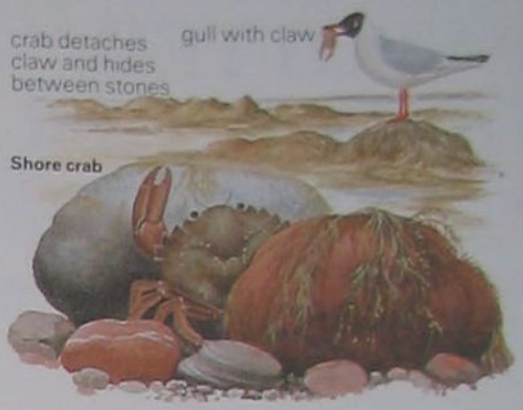
Another safety device, most characteristic of juveniles, involves the shedding of a limb if this is seized by a predator. This drastic response to attack is not entirely without danger. The limb must be broken off at a predetermined region where a partition and blood clot seal the opening of the limb and prevent the crab from bleeding to death. A new limb is eventually regenerated and, in young crabs, can attain full size after one moult.

Adult crab defence Voluntary limb shedding ceases when the crab reaches full size. One defensive trait often used by fully grown shore crabs is the adoption of an aggressive posture, in which the crab raises its claws and extends them outwards while facing an adversary. The effect of this apparent sudden enlargement of the crab may momentarily confuse a predator, giving the crab sufficient time to back into a suitable crevice. Similar displays are used when crabs encounter others of their own species, and appear to be a means of signalling their territorial rights.

One spider crab species, the thornback (*Maja squinado*), has an ingenious means of protection–it forms large mounds of some 50-100 individuals or more. The centre of the mound conceals moulting and mating crabs. The thornback, and other spider crab species, camouflage their bodies with pieces of weed and sponge. The scorpion spider crab (*Inachus dorsettensis*) even mimics seaweed fronds by spreading out its often weed-covered legs horizontally, and slowly moving them to imitate swaying weed. Leach's spider crab (*Inachus phalangium*) and the long-legged spider crab (*Macropodia rostrata*) are sometimes found clinging to the base of snakelocks anemones, whose stinging cells in the overhanging tentacles may offer protection against predators. Often the dense tangle of tentacles conceals the spider crab from sight altogether.

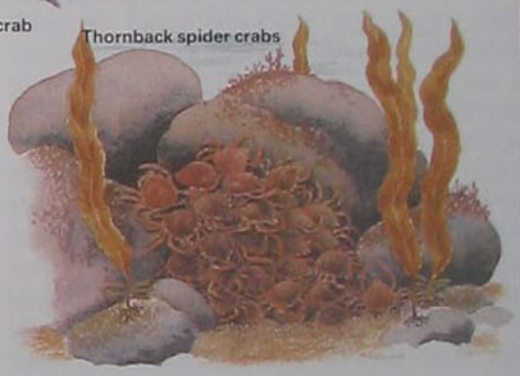
Crab defence tactics

Right: A typical instance of the use of limb-shedding as an emergency tactic. The gull is left with only a portion of its intended prize, and the crab has time to retreat into a crevice, with a good chance of surviving the incident. Its only other tactic for use against this form of attack would be to seize the gull's bill with its free claw.



Left: A safe hiding place for two spider crab species is under the tentacles of the snakelocks anemone. The crab is then partly concealed, and probably also benefits from the protection afforded by the anemone's own defence system–stinging cells in the tentacles.

Right: Divers in inshore waters may occasionally see a mound of thornback spider crabs. These animals, each about the size of a man's hand, assemble in spring and summer and form large mounds to protect the females at the base, which have to undergo moulting before mating.



Above left: A small spider crab (*Inachus dorhynchus*) photographed off the coast of Rhum in western Scotland. The animal disguises itself with small pieces of seaweed which it attaches to its body and limbs. Sometimes these crabs can be seen with considerably more seaweed than this one.

Left: An old man's face crab (*Atelecyclus rotundatus*) immediately after moulting. Its old shell is on the left–the crab emerges hind end first. The newly moulted crab is very soft and begins to expand immediately by taking in water.

WATCH THE SPOTTED FLYCATCHER

Much is known about spotted flycatchers on their breeding grounds from research carried out in the 1970s on six British pairs on a site near Oxford.

The spotted flycatcher is one of the last of our summer migrants to reach us each spring. The species is seldom recorded in any significant numbers before the beginning of May, and late arrivals may not reach us until early June. They are small, brownish-grey birds with pale underparts, which are streaked with brown at the sides. They are instantly identifiable from their behaviour: they sit upright on exposed perches and dart out on short, looping flights to catch insects. For the most part, they return to the same perch before making another sortie. They are generally found in open woodland, areas of parkland and particularly in old, mature gardens. On migration they may be seen along coastal cliffs, or even in wholly open country.

Hurried breeding season The breeding birds are highly territorial, and generally obtain all their food within their territory–sometimes, in prime habitat, as little as half a hectare. The male often feeds the female when the two birds are establishing a pair bond and this food is very important to her. This behaviour continues during the egg-laying period, during which almost a third of her food may come from the male. Courtship feeding is a time-saving device, and must be important for a species which is such a late migrant and therefore has to cram all its breeding activity in a short period.

Some early pairs may lay eggs in the first week of May, but most do not lay until the second half of the month or even later. Unlike many species of migrants, the adults do not have to go through a complete moult while they are in Britain, and so many pairs have sufficient time to rear two broods.

The nest is generally built against a wall, tree-trunk or rock, and often commands a good view of the surrounding area. Spotted flycatchers frequently use open-fronted nest-boxes of the type often put up for robins. If you wish to attract spotted flycatchers, the best site to erect such a box is on a wall, 3-4m (10-12ft) from the ground in a place where the foliage of a climbing shrub conceals it. You can improve the chances of occupation by judicious pruning in the early spring, to ensure that the vegetation is not too thick in front of the entrance. Alternatively, you can make a really attractive semi-natural site by removing half a brick from a wall.

The nest, whether built inside a nestbox or on a natural site, is constructed from mosses, fine grasses, wool and hair compacted together by the use of cobwebs. Even where spotted flycatchers occupy such restricted sites as a disused swallow's nest, they always build this characteristic nest of their own inside it.

The female lays a clutch of four or five eggs which have a greenish pale ground colour and dark red-brown spots: the spots are quite often concentrated at the blunt end of the egg. Most of the incubation is done by the female, and the male may still feed her on the nest, although she regularly leaves the nest for a swift bout of feeding on her own.

The chicks hatch after just under a fortnight, and they fledge 12-15 days later. Both parents feed them, bringing large food items to the nest in their bills. They continue to feed the young for several days after they have left the nest, and it is at this stage that the spotted

Above: Birdwatchers often notice when a spotted flycatcher has caught a butterfly, but the Oxford research showed that these catches, while conspicuous, are relatively rare at about 1% of total prey. This bird has a small tortoiseshell.

flycatcher is at its most vociferous, with the sharp squeaks of several young birds echoing round the territory.

Marathon migrant The spotted flycatcher is a very long distance migrant. An individual ringed on Bardsey Island, North Wales, was later found in South Africa–and this is typical of the whole species. By comparison, many of our warbler and chat summer migrants spend the winter just south of the Sahara, in West Africa.

The spotted flycatchers accomplish this long migration in a series of stages. The first takes them to Spain or Portugal, or possibly to southern France. Next they may go to North Africa, although some probably cross the

Spotted flycatcher

Sahara on their second leg. There will then be two or three more flights before they reach their southern wintering area.

Each flight, of a thousand or more kilometres, lasts more than 24 hours, and the birds derive their great endurance from the use of subcutaneous fat as fuel. Efficient feeding at the various stop-over points, so as to lay down this fat, is therefore crucial to the survival of the species. The strategy of long migration depends on reliable supplies along the route.

Feather maintenance Spotted flycatchers rely on their skill in catching insects in flight. In the warmer countries they visit on migration, they can almost always find more food than on the breeding grounds in a bad English summer. The skill of aerial hunting depends implicitly on good feather maintenance, and the flycatchers spend quite a lot of their time preening their feathers for reliable, accurate flight.

The only complete moult, when the flight feathers are renewed, takes place in southern Africa, and happens very rapidly. Indeed, it is possible that the birds lose their ability to fly

Above: To catch insects, it helps to start from a perch with a good all-round view–an overhead wire is as good as any.

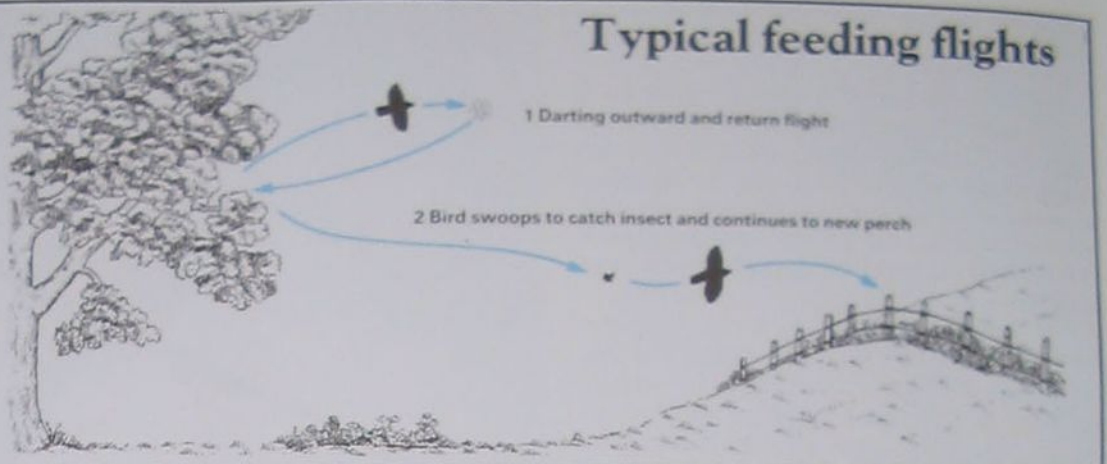
Spotted flycatcher (*Muscicapa striata*). Summer visitor to woodland with mature trees. Long-distance migrant. Sexes alike. 14cm (5½in).

Below: Spotted flycatchers require a ready-made hollow for nesting, especially one with a good view, like this hole in the wall.

altogether for a few days. This would cause their death in Britain, but in the areas in which they moult the birds can rely on a plentiful supply of ground-dwelling invertebrates and larvae, which they gather without flying. The spotted flycatcher's moult is unique among all passerine birds, in that the main flight feathers (the primaries) are moulted from the outside inwards. The other passerines moult their primaries from the middle of the wing outwards.

What do they catch? The conspicuous feeding behaviour of the spotted flycatcher has made it an ideal subject of detailed study. One researcher (Nick Davies) spent a great deal of time in the summers of 1974 and 1975 watching six pairs of spotted flycatchers near Oxford. He found that there were two main types of feeding behaviour: either the familiar dashes for large insects or, if the weather was

During the Oxford research observations it was noted that the spotted flycatcher's success rate from a perch determined where it went after each feeding attempt. If it had to wait on a perch for a long time before seeing another insect, the bird would move to another perch. If successful flights were frequent, it would continue using its perch while insects remain.

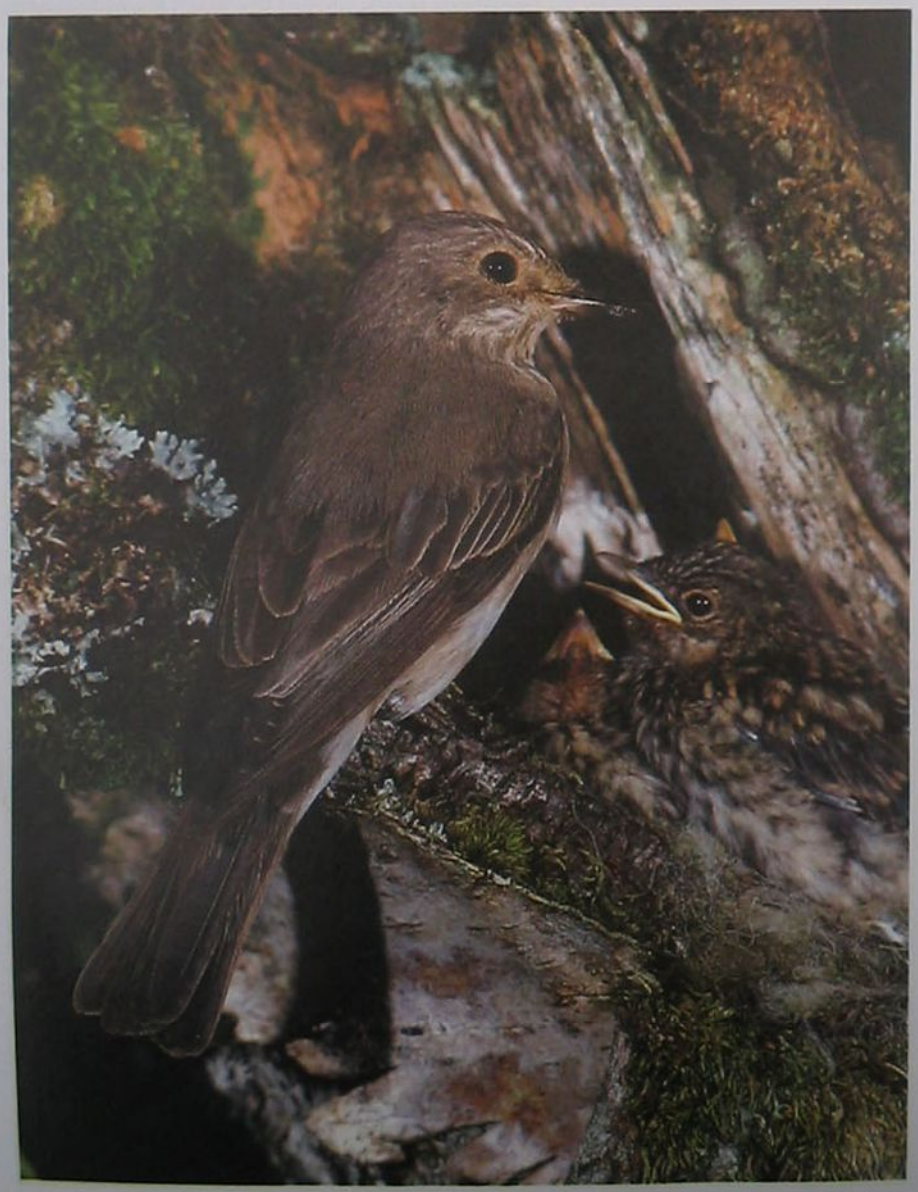


Opposite right: A spotted flycatcher's nest, with eggs, in a hollow that has formed naturally in the top of a tree stump.

Below: A parent spotted flycatcher with vociferous young. The young are more spotted than the adults.

so cold that these were not flying, flitting around in the tops of trees and taking much smaller food items.

On warm days, the six pairs of birds preferred to take large two-winged insects such as hoverflies, rather than bees or wasps. The problem with the latter is their stings, and while the flycatchers are quite able to extract an insect's sting, this takes up valuable time that they could spend feeding on insects



without stings. The birds were seen to eat a number of bumble bees, and these were important because they begin flying earlier in the day than other large insects, thus providing a useful 'breakfast' when no hoverflies are about. (Unlike other insects, bumble bees can generate their own warmth and do not have to wait for the surrounding temperature to rise.)

Many hoverfly species have evolved coloration like that of wasps or bees, and these look-alikes often fool many humans. They are not quite good enough, however, to fool spotted flycatchers, which were never seen to waste time trying to remove stings from them. To remove a bee or wasp sting, they rub its abdomen on their perch until the sting is gone.

Another finding of the observations was that food items brought back to the nest are consistently larger than the average prey. This is because the birds carry food in their bills, and cannot carry more than one item without the risk of dropping the first. Also the energy spent making the flight to the nest is used more efficiently in taking a large piece of food. Butterflies, though occasionally noticed, are not common prey items, for they elude capture with their erratic flight.

Avian architecture

House martin: mud nest shaped like a quarter globe with a slit entrance, just below the ceiling or eaves.
Magpie: large nest in upper branches of a tree.
Greenfinch: cup shape, well camouflaged, close to ground in brambles or thicket.
Long-tailed tit: neat dome of grass and mosses, with a side entrance.
Goldcrest: woven from grasses, hanging from a branch like a hammock.
Thrush: mud-lined nest with downy interior, often in middle height of tree.
Collared dove: sprawling twig nest, often on a roof or other man-made structure.
Buzzard: the nest is reoccupied each year and new sticks are added to its bulk.
Spotted flycatcher: in the axis of a broken branch, with a clear view.
Wren: small nest in any convenient place, such as the roots of a fallen tree.
Great crested grebe: a floating nest woven among reeds as a mooring.
Meadow pipit: inconspicuous nest hidden in a tuft of grass.

DOWN IN THE DUMP: COMPOST HEAP LIFE

To many people a compost heap is nothing more than a pile of useless rubbish–a dumping ground for kitchen waste and garden weeds. But inside, the heap teems with life–from the swarming (and beneficial) bacteria, worms, proliferating fungi and insects, to hibernating snakes or toads.

Below: Well-kept compost heaps in a large garden. All the many millions of micro-organisms in such heaps are essential if the material is to be of any use. Drainage is important since the micro-organisms cannot act properly under water-logged conditions–instead of crumbly compost you may end up with a soggy, smelly mess. Usable compost is friable and sweet-smelling, with no recognisable plant remains.

A well-made compost heap can rapidly turn waste vegetable matter–old cabbage stalks, tea leaves, potato peelings, grass cuttings, and so on–into valuable plant food for spreading on the garden and feeding the next generation of flowers and vegetables. The process depends upon the activities of armies of microscopic plants and animals, and some larger organisms as well, which feed upon the refuse and break it down gradually into simple substances which can be absorbed by plant roots. This is, of course, exactly what happens to fallen leaves and other dead vegetation in natural habitats: it is nature's way of recycling her materials.

The compost community If you dig into the centre of a compost heap you will find it remarkably warm: the temperature may reach 60°C (140°F), thanks to the activities of millions of unseen bacteria. Their chemical attack on the softer plant materials releases energy in the form of heat, which effectively cooks the material in the centre of the heap. Most living things, including weed seeds, are killed by the heat. The temperature is obviously lower towards the outside of the heap and weeds are not always killed here.

A powerful microscope is needed to see the bacteria and the many other micro-organisms, such as protozoans and actinomycetes, that inhabit the compost, but some of the fungi are easier to see. Look for their fluffy threads spreading over dead leaves around the edge of the heap. Many of the fungi are simple moulds, and you might see the spore capsules of *Mucor* on rotting fruit or

Below: Quite a find in a compost heap–the egg batch of a slug. These round, transparent eggs can be produced by any slug, since these animals are hermaphrodites.

Left: *Lithobius forficatus*, a centipede commonly seen in compost heaps, where it can find a wide range of small invertebrate animals to feed on.

Below: A grass snake–this species may well be attracted to the heat within a compost heap for hibernation during the winter. If you disturb one, it may react like the one shown here and 'feign death'.

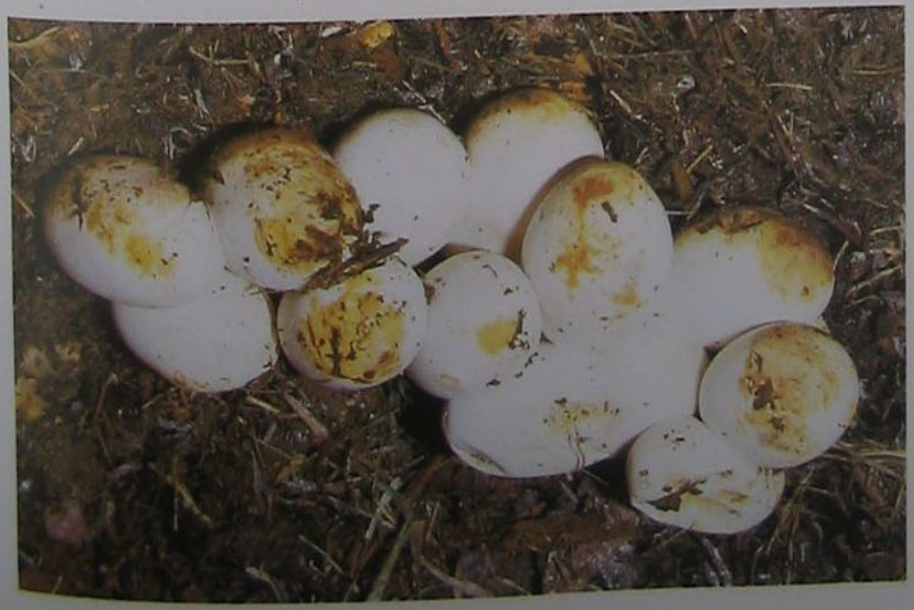
other food. The capsules are like minute black pin heads on slender stalks, giving the fungus its common name of pin mould. You will sometimes find delicate toadstools, such as *Psathyrella gracilis*, sprouting from the edge of the heap. The fungal threads all help to break down dead leaves and twigs and soften them up for further assault by bacteria and an assortment of small animals.

Huge numbers of animals belong to the compost community. Many are microscopic, but others can be seen with a simple magnifying glass or even with the naked eye. These animals include both vegetarian and predatory species, all bound up in elaborate food webs. Those that actually eat the decaying vegetation do not always digest it fully, but they always break the material up into small particles before passing it out in their droppings. It is then much easier for the bacteria to get to work on the material and finally reduce it to the structureless organic matter that we call humus–matter that is essential to the maintenance of soil fertility. The dead bodies of the animals also contribute to the richness of the compost.

Worms and other legless residents Several species of earthworms invade the outer parts of the compost heap and contribute significantly to the processes of decomposition by dragging plant remains in to where they are more readily attacked by the bacteria. The worms' droppings also contain finely divided organic matter mixed with valuable minerals. One of the most conspicuous species in the compost heap, especially where animal dung is incorporated in it, is the brandling (*Eisenia foetida*), which is purplish brown with bold orange bands. *E. rosea* is also very common, and easily recognised when adult by its bright pink body and very swollen orange clitellum.

Related to the earthworms, although much smaller, are the pot worms or enchytraeids. These are small white worms which you will often see in clusters among the decaying leaves on the outside of the compost heap. No more than a centimetre long, they feed on decaying matter. They could be mistaken for fly maggots, but they have no obvious head such as is found in most compost-inhabiting fly larvae.

Below: A batch of grass snake eggs–also a likely find in a compost heap. These eggs are not guarded or incubated by the female snake–once they are laid she abandons them to their fate. The eggs take about six to ten weeks to hatch, the young usually emerging around late August.



Examination of some of the less decayed material from the outer part of the heap with a microscope may well reveal numerous silvery 'hairs' waving about. These are roundworms, or nematodes–among the most numerous of all animals. There will be millions in your compost heap. Some are predators of the protozoans, but most are scavengers feeding on the decaying material itself and contributing to its eventual conversion to humus.

The decaying matter of the compost heap attracts large numbers of slugs and snails, belonging to several different species. Largest and certainly the most interesting of the slugs is the great grey slug (*Limax maximus*). Up to 18cm (7in) long, this mottled grey creature may form quite large colonies on the compost heap. Resist the temptation to remove it, for it feeds only on fungi and decaying matter and does no harm in the garden. The pearly white eggs of these slugs are commonly found in the compost heap.

Among the commonest snails is the cellar glass snail, a pale grey animal with a pale brown glassy shell. Its smaller cousin, the

Opposite left: A common toad catching a beetle larva on the end of its long sticky tongue. Like the grass snake, the toad finds the heat of the compost heap ideal for comfortable hibernation in the winter months. Even during the rest of the year the toad, which is mainly a nocturnal animal, may hide away in the compost heap, only emerging to begin hunting as dusk falls. Compost heaps can therefore be regarded as a useful contribution to toad conservation.

garlic glass snail, may occur with it. The shell of this species is much darker and shinier, and the animal smells strongly of garlic when handled.

Numerous flies breed in compost heaps, and their legless larvae wriggle thoughout the moister parts of the heap. The pale-bodied, black-headed larvae of the fungus gnats are especially common. Even the adults crawl about in the compost. They are very delicate, hump-backed flies and are often accompanied by numerous moth-flies or owl-midges. These are very small flies with pointed wings densely clothed with hair. Their tiny larvae are white and pointed at both ends.

Many-legged animals The mites are usually the most conspicuous of the arthropods to be seen when the compost is examined closely. They are very numerous and they move about freely. Many are spiky creatures with relatively long legs, while others look more like mobile sand grains–encased in smooth shells with tiny legs protruding just enough to trundle the animal slowly along. The mites imbibe fluids from living and dead organisms, with fungal threads playing a major role in their nourishment. Springtails are also very common, leaping vigorously about when disturbed but otherwise wandering slowly and chewing the decaying matter. Both groups fall victim to the fascinating false scorpions–miniature versions of the real thing except that they lack the tail and sting. Although the animals are only 2-3mm long, their pink claws look distinctly menacing as they creep slowly through the compost. False scorpions are by no means abundant, but they are well worth looking for; if touched, they pull in their claws and scuttle backwards at a remarkable rate.

Centipedes find a wide range of suitable prey in the compost heap and are therefore quite numerous. Most individuals are of the species *Lithobius forficatus*–shining brown and moving very quickly on their 15 pairs of legs. They are about 3cm (1in) long when mature. The flat-backed millipede (*Polydesmus angustus*) is often mistaken for a centipede. It is much the same colour as *Lithobius*, but a close look will reveal two pairs of legs on each segment, not one as in centipedes. Like the other millipedes, *Polydesmus* is a vegetarian and it revels in the decaying vegetation of the compost heap. You might even find one standing guard over its nest–a small chamber fashioned from its own excrement and saliva. Woodlice also revel in the moist conditions of the compost heap. Large species such as *Oniscus asellus* are usually very obvious, especially at night, but the most common species–*Trichoniscus pusillus* and *T. pygmaeus* –need to be searched for because they are under 5mm long.

Above: Many different types of fungi can be found growing in profusion in compost heaps, from simple moulds to such delicate toadstools as this *Psathyrella gracilis*. The fungal threads help to break down vegetable matter–dead leaves, twigs, cabbage stalks, potato peels, apple cores and so on–and so soften them up sufficiently for bacteria to move in and continue the process.

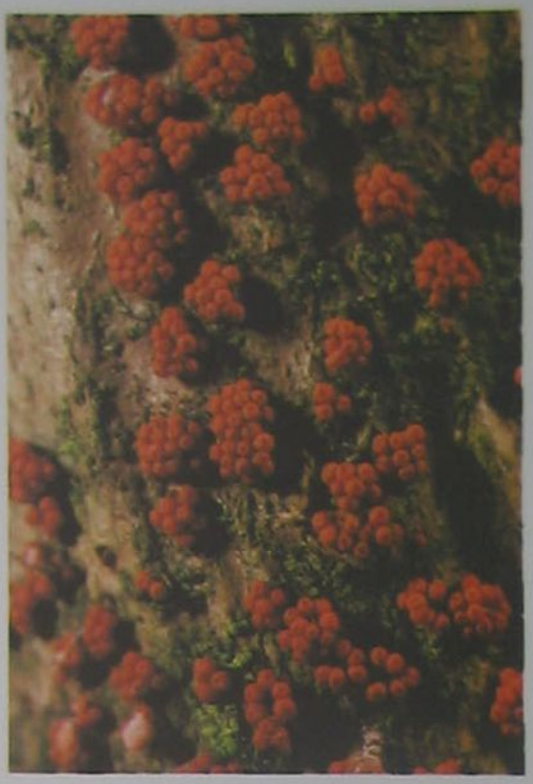
Compost lodgers The abundance of small animals in the compost heap attracts plenty of predatory creatures which may take up temporary residence. These lodgers include numerous beetles, such as the devil's coach-horse and the violet ground beetle–both fond of a good meal of slugs–and also a variety of larger animals such as the hedgehog. The

Left: The moist conditions of the compost heap are ideal for woodlice, and several species can often be found there. The one that is easiest to see because it is fairly large is the one shown here–*Oniscus asellus*. This species, and the even commoner but much smaller *Trichoniscus pusillus* and *Trichoniscus pygmaeus*, are most active during the hours of darkness.

warmth of the compost heap is an added attraction for some of these larger animals, and it is not uncommon for hedgehogs, grass snakes and slow-worms to nest there. They may also use the heap for hibernation, together with frogs, toads, and newts. The compost heap can thus be regarded as a useful contribution to their conservation.

Less welcome lodgers are the rats and mice which frequently excavate snug nests for themselves and their young, emerging at night to sniff out our freshly sown peas and beans. The wasp is another generally unwelcome lodger, although there is no denying its value in controlling garden pests. It is likely to nest in your compost heap only if there is a fair amount of uncompacted twiggy material from which it can hang its nest. Bumble bees are more frequent lodgers, often taking over abandoned mouse nests in the heap. It is possible to watch their comings and goings throughout the summer and to see just how much pollen they bring in on their hind legs. Keep your eyes open for the remains of any nests and the bees' waxy cocoons when spreading the mature compost on the garden.

Right: The woodier components of the compost heap often support the attractive pink or orange pustules of the coral-spot fungus, which occurs regularly on old pea sticks.



Below: A compost heap can provide food and shelter for a host of animals.
1 Bumble bee and nest.
2 Ground beetle–preys on small invertebrates.
3 Springtail–feeds on vegetable debris, algae etc.
4 Robin–our best-known insectivorous garden bird.
5 Garlic grass snail–shelters within the heap.
6 Brandling earthworm–a common compost worm.
7 *Mucor* fungus with spore capsules.
8 Hedgehog–hibernates in the warm, dry heap.
9 *Actinomyces* bacteria–vital in the breakdown of organic matter.

Compost heap creatures

HERDING HABITS OF NATIVE PONIES

Although British native ponies show the same type of herd structure and behaviour as other horses and ponies living in wild or semi-wild conditions, there are variations, particularly the strongly defined hierarchy among the mares of a herd.

Left: Welsh ponies in the Brecon Beacons National Park. In the British Isles horses no longer live in herds –except for some breeds of native ponies. Some Shetlands, a few Highlands, some Fells and a significant number of New Forest ponies still live in at least a semi-wild state in their natural surroundings, and among these it is still possible to observe herd structure and behaviour. Of the Dartmoor ponies (below) there are now few pure-breds left in their native habitat, though in the past there were large herds which would have conformed with the herd structure of other British native ponies.

During televised show jumping commentators sometimes say 'that fence is causing problems–because the horse is jumping away from the collecting ring', or 'the horse is napping (trying to return) to the collecting ring'. In terms of show jumping this is disobedience, but in terms of equine behaviour the horse's actions are easily understood. Equines in the wild are herd animals, and even horses bred away from their natural surroundings for generations still retain the instinct to return to or remain with others of their kind. For show jumpers, this means returning to where their fellows are waiting in the collecting ring.

British ponies Some British native ponies live in a semi-wild state and differ in at least one aspect from those equines living under wholly natural conditions: there are far fewer males due to management policies by the owners. In the New Forest, for instance, something under 200 males (a high proportion of which are turned out on the Forest only for the breeding season) run with anything up to 2500 or 3000 mares. This compares with a

herd of truly feral horses in the United States which consisted of 270 animals with an almost equal division of the sexes. Under British conditions, the majority of males are removed at an early stage. This clearly influences herd structure, but, except during the breeding season, it appears to make little difference to herd behaviour.

In the British Isles, herds of 50 or more ponies occupy home ranges containing winter and summer food, water and shelter. At first sight it appears that the entire herd moves freely over that area, especially in daylight hours, but closer examination shows that individual herds are divided into smaller groups, each with its own smaller range that nearly always overlaps with those of neighbouring small groups.

The smaller groups usually consist of a mature mare (sometimes two, occasionally more), with a varying number of offspring. Most colts are removed from the New Forest during their first, or at least their second year, but the remaining fillies stay with their mother until their fourth or fifth year; then they usually leave the group, either to remain alone until they start another group with their own offspring, or to join another single mare. Sometimes they join another unrelated group.

Mare groups Among truly feral horses each mare group is headed by a stallion (usually a mature animal), and the surplus (younger) males form bachelor groups. However, in this country the comparatively small number of stallions that live all year with the herd, and those that are turned out for the breeding season only, tend to spend more time with one mare family group. This suggests that if more natural conditions were possible, native ponies, too, would fall in line with most other horses and maintain groups of mares with a single stallion.

Among the mares of the herd there is a more or less clearly defined 'pecking order' which is directly related to size and is evident in all situations. Mature stallions, when present, are usually dominant over the mares, but it is not unusual for a high-ranking mare to threaten a stallion if he approaches her foal too closely, or in winter when there is competition for hay that is put out by the ponies' owners.

Hierarchy Dominance is established by a range of threatening behaviour patterns. The mildest consists of a simple laying back of ears, but may be followed by biting or, more seriously, by kicking with one or both hind legs. Actual fights, involving bouts of kicking, occasionally occur.

Threats are more often provoked by the trespass of one pony within another's 'individual distance'–an area of variable size which each pony regards as its own territory at a given time. Although ponies do guard their individual distances, as a herd they do not show the rigid territorial behaviour seen in, for example, some bird species. Each family group has its own range, but there is rarely an aggressive reaction if a strange animal strays within that area. The only consistent exception to this occurs during the breeding season when stallions chase off rivals from adjoining herds.

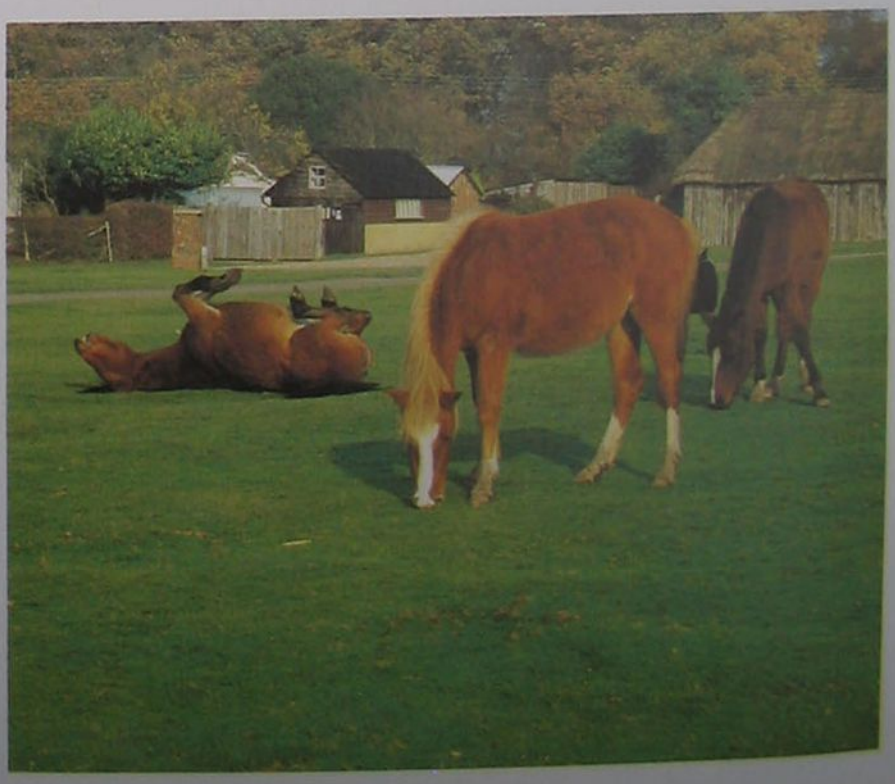
The whole herd shows distinct patterns of movement within the total home range. Depending on the weather there is a regular pattern of movement between morning, afternoon and night feeding areas, and there are also seasonal movements. For instance, ponies move to one part of the range searching for acorns in late autumn–an area they may rarely frequent at other times of the year.

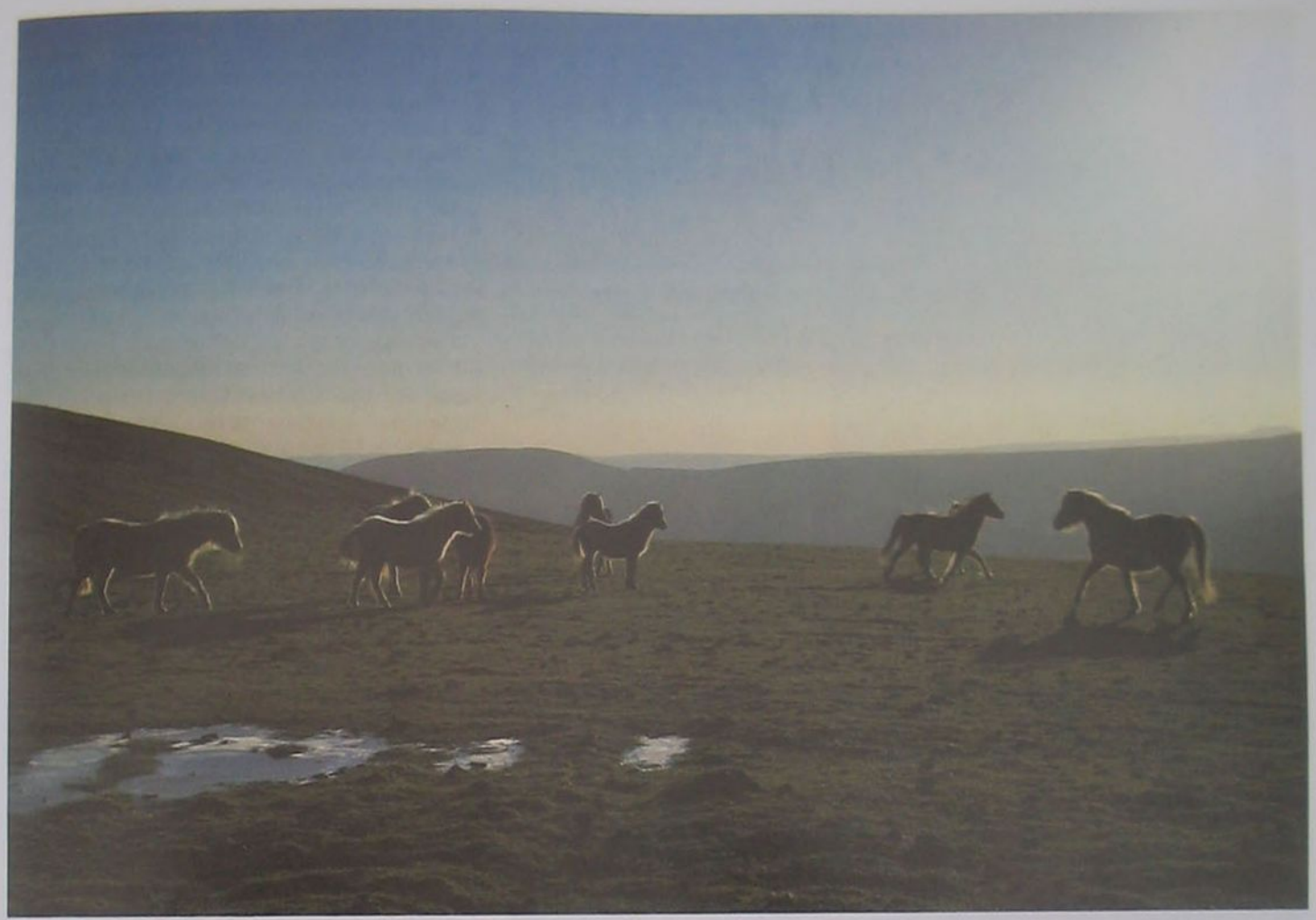
Movement through the home ranges is not necessarily initiated by a dominant

Left: Mutual grooming among Welsh pony foals. They nibble each other's neck, mane and withers–the parts the animals cannot reach themselves. This is most common in spring, midsummer and winter and is believed to strengthen the bonds between the family or near neighbouring groups. Surprisingly it is unusual for the dominant animal to initiate the activity, but it is almost always the dominant one that terminates it.

Shading

During summer ponies often move as a herd to 'shade' during the heat of the day. This is a phenomenon observed in New Forest ponies but not other breeds. Shading is when the ponies congregate in a tight group on a particular area of ground, often out in the open, where they seek relief not from the sun but from biting flies. The 'shades' are apparently areas where there is sufficient air movement to discourage the presence of insects.





Above: Dawn breaks over the Welsh Mountains and a group of native ponies.

Below: A dominant New Forest mare and her offspring –this year's foal and a two-year old. She will eventually lead off and the others will follow. Rolling (bottom left) is usually initiated by one member of the herd and the others often follow suit. This behaviour is believed to relieve the itch of parasites.

animal, but the leadership is frequently taken over by a dominant mare, and the others follow in something approaching the established pecking order. Once again, because of interference by man, it is not easy to determine the role of stallions in normal herd or group movement. Observations show that they usually follow the herd, particularly when the ponies are moving away from possible danger, and this has been interpreted as the stallion putting himself between his mares and any source of danger.

During the breeding season, there is a certain amount of 'harem formation' by pony stallions. Each stallion begins the active herding and driving of one or a number of groups of mares. His attitude at this time is typical–ears laid flat against the head which is held low as it shakes and sways in an almost snake like manner. If more than one stallion is turned out in the same area, each herds his own group of mares, and chases and rounds up any that stray. Fights between neighbouring stallions are relatively common, but rarely result in serious injury. The fights differ from those between mares in that the stallions attack with their front feet, rearing up and striking out viciously at the adversary, as well as kicking with their hind feet and biting.

Communication There is a variety of social interactions between members of equine herds, and the ponies are no exceptions. The sounds or 'vocalisations' emitted by horses and ponies may be divided into four different types–the snort, squeal, nicker (or whicker) and the whinny. The first two are normally sounds of aggression, but the latter two may be regarded more as communication between the members of the group or herd. The nicker or whicker is a low-pitched call used between mares and their foals and vice versa, and sometimes as an alarm call. The whinny is a much louder, more definite high-pitched call, and is used almost exclusively when a pony is separated either by sight or distance from the herd. Another more direct form of social contact is mutual grooming, particularly in March and April, June to August and again in the winter.

TACHINIDS: LARVAL PARASITOIDS

Anyone who has reared caterpillars is familiar with the disappointment of seeing the caterpillars die, only to be replaced by the barrel-shaped pupal cases of tachinid flies–a large family of flies whose larvae feed internally on caterpillars.

Above: *Tachina fera* is an extremely common fly found in late summer on water mint, and on a variety of garden flowers. It can be recognised by its dull orange abdomen, marked with a broad central dark stripe. The larvae parasitise the caterpillars of the cabbage white butterfly and a number of moths.

Left: This long legged fly, *Dexiosoma caninum*, occurs on bracken in summer. The females lay their eggs in soil near cockchafer larvae so that when they hatch the fly larvae can easily find a host.

Most tachinids, of which about 250 species are found in Britain, are very ordinary looking flies. With their predominant colours of black, grey and brown, they can easily be mistaken at first sight for houseflies or some kind of blowfly. Some species are long and narrow with long legs, but in others the abdomen is much broader and often reddish at the sides. All are rather bristly and tend to rest with their wings half open. The females, when looking for hosts, have a busy, searching flight which is fairly distinctive.

Parasitic larvae As with ichneumon wasps, the larvae of the Tachinidae obtain their food from the body tissues of their hosts–moth and butterfly caterpillars mainly, but also sawfly and beetle larvae and nymphs and adults of the Hemiptera. When the larvae are fully grown within their host they either change to pupae in barrel-shaped pupal cases within the dead host's skin or more usually bore out and form their pupae and pupal cases in the soil. (The brown pupal case, in common with that of all higher flies, is the hardened last larval skin which forms a case for the pupa within.)

Finding a host While ichneumons seek out their hosts and lay eggs either in or on the hosts' body, using their sharp ovipositor, tachinid larvae (all of which are internal parasites) find their way into their hosts in a variety of different ways. This is partly because the females do not normally have a sharp ovipositor.

In the simplest method, the females of such species as *Phryxe vulgaris* and *Phryxe nemea* search out hosts and actually cement their slightly flattened eggs to the hosts' skin. The flies' eggs sometimes hatch immediately or there may be a delay but in both cases the newly hatched larvae rapidly bore through the skin and into the hosts' bodies. The hosts sometimes try to shake off the parasitic larvae, but usually they are indifferent. The eggs often fall off, though, or may come away with cast skins.

An advance on this method is shown by some tachinids, for example *Compsilura concinna*, which have developed a sharp ovipositor or a special spine with which to pierce the host's skin so that eggs or larvae can be directly inserted within the host's body.

Some female tachinid flies retain their eggs in a special body chamber until they hatch, and can thus lay active larvae; the females lay between 100 and 200 eggs or larvae. If too many larvae invade a host some may die. Most are solitary parasites however, but up to half a dozen in one host are known to occur.

A chance in a hundred What appears to be a more haphazard method of host location is that used by numerous species which glue vast numbers of tiny dark eggs to the leaves of plants used as food by suitable hosts. Each female lays several thousand eggs–usually 2000-3000, although higher figures have been recorded. These eggs remain able to hatch for six weeks, but they do not do so until they are

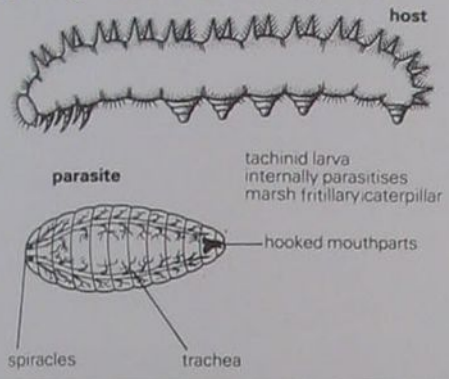
swallowed with the foodplant by the host, usually a caterpillar or sawfly larva. The fly larvae then hatch within the caterpillar's intestines before migrating to other parts of the host's body.

Another group of tachinid flies, including *Tachina grossa*, one of our bulkiest species, similarly lay small eggs in the neighbourhood of suitable hosts. These hatch immediately into tiny migratory larvae which actively search for hosts into which they quickly bore. The females of these species lay 400-1000 eggs and the larvae are frequently armoured to prevent desiccation.

Although these host-locating methods appear rather a gamble, many of the species are quite common, so they clearly work well, the number of eggs laid making up for losses through failure to find hosts.

Right: By far the bulkiest species in the tachinid family is *Tachina grossa*, a black bristly fly with a yellow head. Fairly common on umbellifers and composite flowers (the daisy family) in England and Scotland, it has a wingspan of 3.5cm (1½in) and is 2cm (¾in) long. The females lay their eggs not far from where the hosts are likely to occur, and when the larvae hatch out they parasitise the caterpillars of brown tail, oak eggar, fox and pine hawk moths.

Living inside a caterpillar



Most tachinid fly larvae parasitise butterfly and moth caterpillars by feeding on their body tissues. They do not, however, inflict fatal damage until late in their larval life. The larvae breathe through spiracles situated at their rear; the hooked mouthparts or raspers at the other end are used to tear off chunks of the host's tissue.

Breathing difficulties Because the parasites are bathed in the host's body fluids, they have the same respiratory problems as aquatic insects. When very small, many can obtain sufficient air for their needs by direct diffusion from the host's tissues, but as they grow bigger and their respiratory requirements increase, it is normal for them to seek communication with atmospheric air. This they do by boring either through the host's skin, or into a main tracheal trunk or spiracle.

Some species overcome the respiratory problem by remaining with their hind ends attached to the original entry hole. The host's reaction to this trauma is to secrete a sheath around the parasitic larva. At first the parasite feeds only on the host's blood and fat, but when in their final larval stage most of them rupture their sheaths and start feeding on the hosts' vital organs, rapidly killing them.

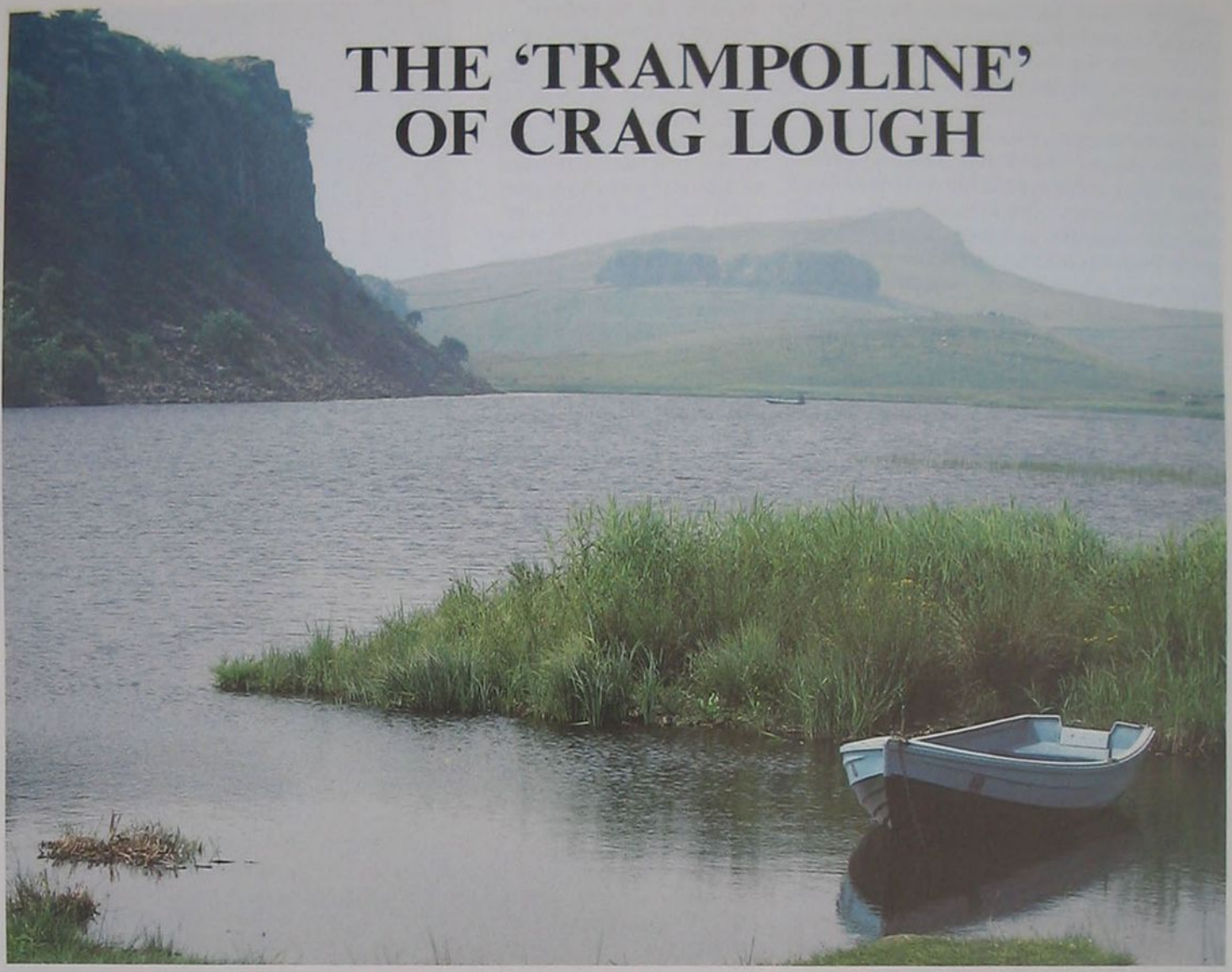
Common species The Tachinidae are clearly a most important family biologically, and play a role in the control of insect numbers only second to that of the ichneumons and their allied parasitic wasps. A number of species have been used in the biological control of insect pests, for example the common British *Compsilura concinna* has been established in America to help control the gypsy moth, an introduced forestry pest.

One of the commonest and most ordinary looking tachinid flies is *Phryxe vulgaris*, 6-9mm long and blackish with a whitish sheen on its abdomen when viewed from certain angles. This species and its relation, *Phryxe nemea*, have each been recorded as parasites of hosts belonging to 15 families and both are very familiar to Lepidopterists. *Compsilura concinna* is a very similar looking fly but has been recorded from an even greater number of hosts, over 100 being known from 18 families of Lepidoptera.

Other common tachinid flies include *Tachina grossa* and *T. fera*, found respectively on umbellifers and water mint, and *Siphona geniculata*, a brownish-grey fly which is often seen probing for nectar on composite flowers from May to October. Its larvae parasitise leather jackets (cranefly larvae). *Gonia divisa* is found in late March or early April, when it can be seen flying low over the ground on heaths and commons. Its tiny eggs are eaten by the caterpillars of noctuid moths and occasionally by the larvae of bumble bees and potter flower bees (*Anthophora*). Both these hosts fly in early spring and are thought to carry the tiny eggs of *Gonia* back to their nest in pollen.

Below: A strange looking fly is *Alophora hemiptera* with its yellow abdominal markings and broad wings. The female is equipped with a sharp backwardly directed ovipositor which she uses for injecting her eggs into plant bugs. On hatching the parasitic fly larva develops in the plant bug's abdomen, which becomes swollen. The host is either killed as soon as the fly larva leaves its abdomen to pupate in the soil, or dies a few days later.

THE 'TRAMPOLINE' OF CRAG LOUGH



Nestling at the base of a 300-foot cliff at the far northern end of the Pennines is Crag Lough, a lake remarkable for its diversity of plants, including a floating 'trampoline' of vegetation upon which the daring–or the foolhardy–can jump up and down.

Above: A view westwards across Crag Lough, with the cliff of Whin Sill on the left. Though the length of the lake is fairly constant at about 850m (930yd), the width fluctuates with the success or otherwise of the various plant communities along the lakeside. During the past century the vegetation on the north side has steadily advanced, though the width of the lake has never been greater than 200m (220yd).

Left: Water horsetail (*Equisetum fluviatile*) is an important constituent of the swamps at the eastern end of the lake.

Crag Lough (pronounced 'loff') lies just within the southern boundary of the Northumberland National Park, very close to the remains of Hadrian's Wall and the ancient fortress of Halstead. The lake forms part of a much larger area designated a *Site of Special Scientific Interest* by the Nature Conservancy Council. The area is known as the Roman Wall SSSI.

The lake lies in a shallow hollow about 240m (800ft) above sea level at the far northern end of the Pennines between the rivers North Tyne and South Tyne. Most of the southern edge of the lake is bordered by the sheer and dramatic cliff called Whin Sill, which rises up 100m (330ft) above the level of the lake. The northern side of Crag Lough, however, consists of very gently sloping fen, swamp and carr.

Features of the lake For such a small lake (it

is only about 850m/930yd long) Crag Lough displays a remarkable array of habitats, which accounts for the wide range of plants found there. The key to the success of many plants is the shallowness of the lake which allows most of the plants therein to photosynthesise efficiently. Over half the lake is less than 1m (3ft) deep, and even the deepest part below the Whin Sill scree does not exceed 2m (6½ft). The water level, however, is not constant and may rise and fall rapidly through a height of more than 25cm (10in).

There are three main types of substrate at the bottom of Crag Lough. At the south-western end of the lake the bottom is dominated by fine, loose organic particles which sometimes become suspended in the water, causing it to turn cloudy. The northern side of the lake also has an organic bottom, but of a quite different nature. It is composed of firm peat which also contains the remains of preserved tree stumps–relics of an ancient wet woodland that once occupied the site more than 5000 years ago. Finally, at the south-eastern end of the lake there is an inorganic bottom with sands, gravels and pebbles.

Despite the presence of peat (which is poor in nutrients and acid) the lake is nevertheless very rich, both in the amount of nutrients it contains and in its level of alkalinity (most plants preferring alkaline rather than acid conditions). This richness contributes greatly to the diversity of plants found in and around the lake.

Aquatic plant communities Each of the three substrates of the lake has given rise to its own community of aquatic plants. At the south-western edge, where the organic detritus is prevalent, the plant community is dominated by the alga, stonewort (*Nitella*). This plant is a delicate pale green–almost translucent–and its branched stems may grow to a length of 1m (3ft). In the summer the axils of the stems bear orange reproductive bodies.

Above: Bogbean (*Menyanthes trifoliata*) has creeping underwater stems that allow it to colonize large areas. At Crag Lough it is one of the plants responsible for creating the floating mat, another being marsh cinquefoil (*Potentilla palustris*)–see right.

Below: A stand of bottle sedge (*Carex rostrata*) with a species of water-plantain at Crag Lough.

In the shallowest water in this section of the lake stonewort is found in association with blunt-leaved pondweed and autumnal water-starwort. This is a common combination in other British lakes, especially in the Lake District, but it is usually found along with the alternate-leaved water-milfoil. In Crag Lough, however, this plant is absent because it prefers more acid, less nutrient-rich, water.

In deeper water, starwort and stonewort are partially or totally replaced by a community of taller plants dominated by pondweeds. Where the water is deepest the vegetation becomes sparse or even totally lacking.

Plants on peat Most of the underwater layer of peat found along the extensive northern edge of the lake is covered by a short compact mat of another plant commonly known as stonewort, but belonging to a different genus to *Nitella*. This is *Chara*, a close relative of *Nitella* but differing in several important ways. Instead of the main stem being com-

posed of single elongated cells, as it is in *Nitella*, it is composed of several intertwining cells. Coming off the central stem at intervals are small branchlets, which are forked in *Nitella* and unforked in Chara. Finally, whereas *Nitella* is translucent, *Chara* is opaque and often heavily encrusted with lime.

Eastern plants At the eastern end of Crag Lough where the organic silts and peat merge into the sands, gravels and pebbles, the plant community becomes particularly interesting. The almost pure mats of *Chara* become interspersed with two species of pondweed: the various-leaved pondweed and, occasionally, the reddish pondweed. This combination of species is exceedingly rare elsewhere in the country.

The eastern corner of Crag Lough provides an excellent illustration of how plant communities can change over the years. Decades ago, this part of the lake contained a mass of floating-leaved vegetation, but less than ten years ago it was much barer and shoreweed, a relative of the plantains, had moved in. Today the scene has changed again because a swamp of reed has developed from fragments of the plants growing in the extensive swamps at the western end of the lake.

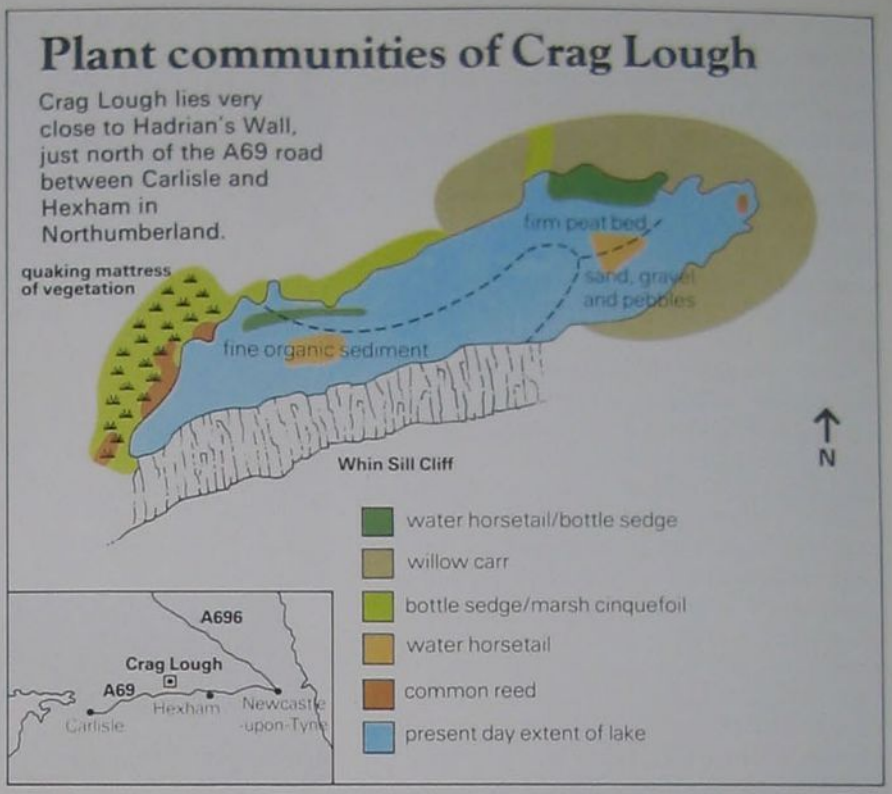
Swamp communities Most of the northern edge of the lake is swamp, the eastern half of which is dominated by willow carr. In the shallowest parts of the lake near the shore the willow carr gives way to a mixture of bottle sedge and water horsetail, with occasionally bogbean and marsh cinquefoil being present as well. Further out into the lake only water horsetail is found; it alone can thrive in open water where the depth of the lake approaches 1.5m (5ft), and even it succeeds only where there is a solid base of peat for it to root into.

The quaking mat The most striking feature of Crag Lough is its quaking mat or vegetation, which occurs along the whole of the north-western shore. Walking and bouncing on this mat is an unforgettable experience, if a little eerie! As you slowly put one foot in front of the other the whole of the surrounding vegetation begins to undulate in step. And if you slowly jump up and down the mat behaves almost like a trampoline–but this is not recommended because you may damage the mat and you may also fall through to the dark and sinister-looking water below. In Crag Lough you are not likely to come to much harm, for the water is never deeper than 1m (3ft) in this part of the lake, though on the Continent there are mats of vegetation above water more than 10m (33ft) deep.

The mat is created by the ability of some plants to be firmly attached to the bank of the lake and then to encroach across the surface of the water in a free-floating form. Two such species are bogbean and marsh cinquefoil. As they grow across the water their matted roots collect debris such as leaf litter and eventually enough floating organic matter builds up to enable other plants to root into this mat. The result is a floating raft of vegetation.

The dominant species in the floating mattresses of Crag Lough are bottle sedge and marsh cinquefoil, with marsh bedstraw, common sedge and wild angelica also common. Among them are a variety of mosses and liverworts capable of thriving on low levels of nutrients. Altogether they form a mat about 30cm (1ft) thick.

At the extreme western edge of the lake bogbean becomes an important constituent of the floating mat, though it is rare further east except along the fringes of the fen where it grows with bottle sedge.



Below: Marsh bedstraw (*Galium palustre*) is a constituent of the floating mat of vegetation, its creeping stems intertwining with those of other plants to form the basis of the mat. Marsh bedstraw is an upright plant growing to a height of 1m (3ft). The leaves have small backward-pointing prickles along their edges; as with other bedstraws, the flowers are tiny (about 3-4mm across).

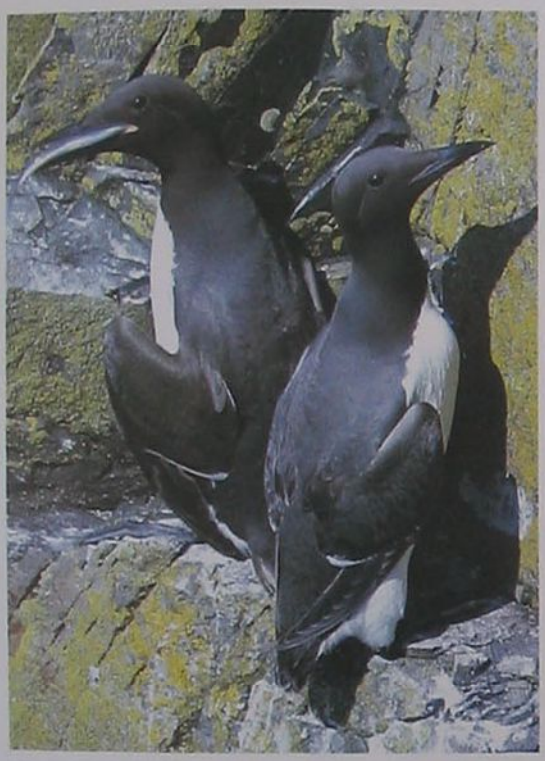
BIRD POPULATIONS AND MORTALITY

Most bird populations are roughly constant. Birds may produce a vast number of eggs each season, but only a few of the chicks that hatch ever become adults–just enough to replace the adults that die in the same period, and maintain the population.

The many species of birds we see in the countryside have all been in existence for thousands, in some cases possibly millions, of years, over innumerable generations. Very obviously, the individual birds are mortal, but it is also certain that, in the majority of British bird species, the actual populations vary little from year to year. What ensures the continued existence of these species, and what guarantees that these natural populations are maintained? This subject has intrigued generations of scientists concerned with all classes of animals and plants, and especially ornithologists finding out about bird populations.

Above: A flock of Brent geese wintering in Britain. By examining the age structure of the flock, ornithologists can tell that there are some years in which breeding failed altogether.

How long is a bird's life? Bird ringing, which has been taking place for most of this century, has given us a good idea of the record ages reached by the longest-lived individuals. The world age record for a wild bird is certainly held by one of a group of albatrosses that were ringed in the sub-Antarctic in the 1930s, for ornithologists know that some are still living from that time. For European birds, an oystercatcher at 36 years holds the record, and individual reports of Arctic terns, guillemots, black-headed gulls, herring gulls and ospreys have shown birds living for more than 30 years. Of familiar land birds only swifts, blackbirds and starlings have exceeded 20 years and of the smaller species only a few, such as reed warblers and robins, have even



Above: The whinchat is an example of the many birds that help themselves to a better chance of surviving winter by migrating to the tropics. At the onset of winter, whinchat pairs have fewer fledglings than, say, the closely related stonechats. But a greater proportion of the young whinchats survive the winter, for stonechats spend this harsh season largely in their breeding range.

Left: A pair of guillemots lays only one egg a year. The same parent bird may return to breed at the same ledge for 20 years or more, barring accidents. From the potential 20 eggs laid in this time, only two new birds need to survive to replace the pair.

reached ten years, although hundreds of thousands of them have been ringed. The tiniest species such as goldcrests, treecreepers and wrens all have records of less than seven years.

Calculations based on ringing results show that, in general, longevity increases in direct proportion with size. For example, a larger bird species with a life span twice as long as that of a smaller one has a body weight around 32 times that of the smaller one. In terms of species, this is roughly the difference between a tawny owl and a blue tit.

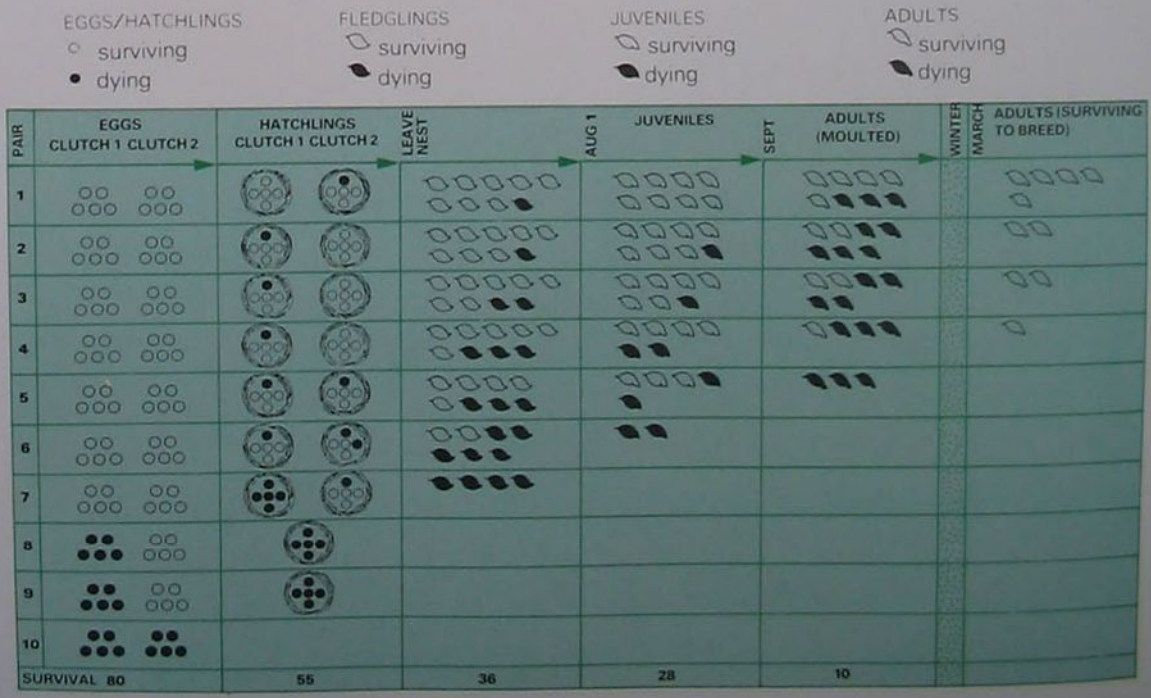
Natural wastage However long individual birds live, it is also true–in many cases–that the total number of members of one species living at any one time is constant. On reflection, it is easy to see how the population levels of birds must be regulated: births and deaths must balance out exactly.

On average, a pair of robins present at the beginning of one breeding season raises five young in each of two broods, making 12 robins in all: speaking from a statistical point of view, this necessitates the death of ten of those birds before the next breeding season. If only nine died in the average family, that would leave three birds for every two that had been present a year before, and the British Isles would already be so crowded with robins that they would not even find space to roost!

In reality, young robins suffer about 90% mortality, while robins over one year old suffer 50% mortality. For smaller birds, or ones particularly vulnerable to cold, the mathematics is more frightening still. A productive pair of goldcrests may rear two broods of ten young, while a pair of kingfishers may have three broods of six young. For these populations to remain stable, each species must suffer about 90% overall mortality. In fact, although their numbers are

Survival of the few

If ten pairs of robins laid two clutches of five eggs each–the average of the species–something similar to what appears in the chart would be bound to follow. (For the sake of clarity, the most successful pairs are arranged at the top, while the failures are all sorted downwards.) Four complete clutches fail before hatching: this is the result of predation, storms etc. Three more clutches fail before fledging. Of the fledged young, only ten survive by the following breeding season. The survival rate is thus 10%.



relatively stable over the medium term, this is hardly true of the short term. In a severe winter, they may suffer enormous losses, but their large numbers of offspring give them a good chance to increase rapidly following a drastic fall in numbers.

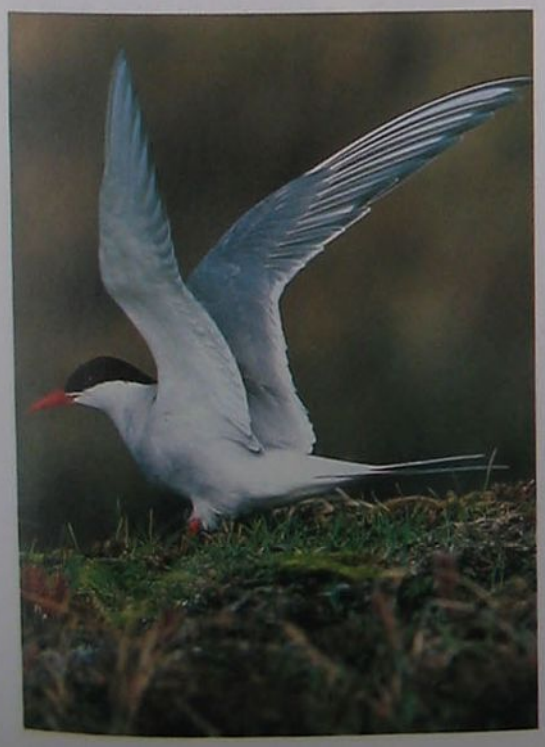
For bigger species, longevity makes a slower and more 'relaxed' rate of breeding possible. A pair of guillemots, for instance, has only one egg each year. Many species in this size range do not start to breed until they are several years old, and may sustain fairly heavy mortality during the years before they are able to start breeding.

Parental care Overall, the outlook for an individual bird is grim indeed. The major problem is the learning period, when the young birds must find out how to feed themselves. Some of the longer-lived species devote a great deal of parental care to the newly fledged youngster, in which they have invested so much effort in breeding. Sandwich terns continue teaching their young how to find food all through the long migration to winter quarters in Africa. On the other hand, most of the small bird species invest their effort in producing a large number of young, but are unable to look after them for more than a week or two after fledging, for they are then preoccupied with bringing up the next brood or preparing for autumn.

Above: Blue tits count among the mass producers of eggs, with ten eggs in the average clutch. Their big-clutch strategy is also a strategy of perfect timing, for an essential feature is that the young hatch at the one time when there are ample caterpillars.

Below left: The Arctic tern follows a small-clutch strategy–one clutch a year, averaging four eggs. To ensure a good rate of survival, the parents look after the fledglings diligently for up to ten weeks.

Below: The mute swan is also a watchful parent, looking after the young for several months until they moult into white plumage.



Diversity of strategies Even closely related birds have evolved widely different strategies in respect of breeding ages, clutch sizes and longevity. For example, among Britain's owls, the barn owl produces a relatively large brood of young (often six or seven), feeding them on the copious supplies of small mammals that appear periodically in open habitats. When the young fledge, they move away from the parental territory quickly and must fend for themselves straight away.

On the other hand the tawny owl, a bird of the same size and feeding also mainly on small mammals, generally has a brood of only one or two young. The parents allow their offspring to stay on the territory, and care for them for up to ten weeks, so ensuring that they are more likely to survive to breeding age.

Merits of migration One might expect that the long migratory flights made by many species of small birds are a time of great hazard and mortality. Certainly there are risks, but the strategy of migration is successful because it avoids the greater mortality of a British winter. The whinchat and stonechat are closely related, but stonechats are virtually all residents, while whinchats winter in West Africa. Stonechats fledge more than twice as many young as whinchats, but both species have survived on these rates of productivity for thousands of years. This must be because a greater proportion of the young whinchats survive the winter, thanks to their lengthy migration. The stonechat faces all the hazards of a British winter.

STONECROPS: PLANTS OF DRY PLACES

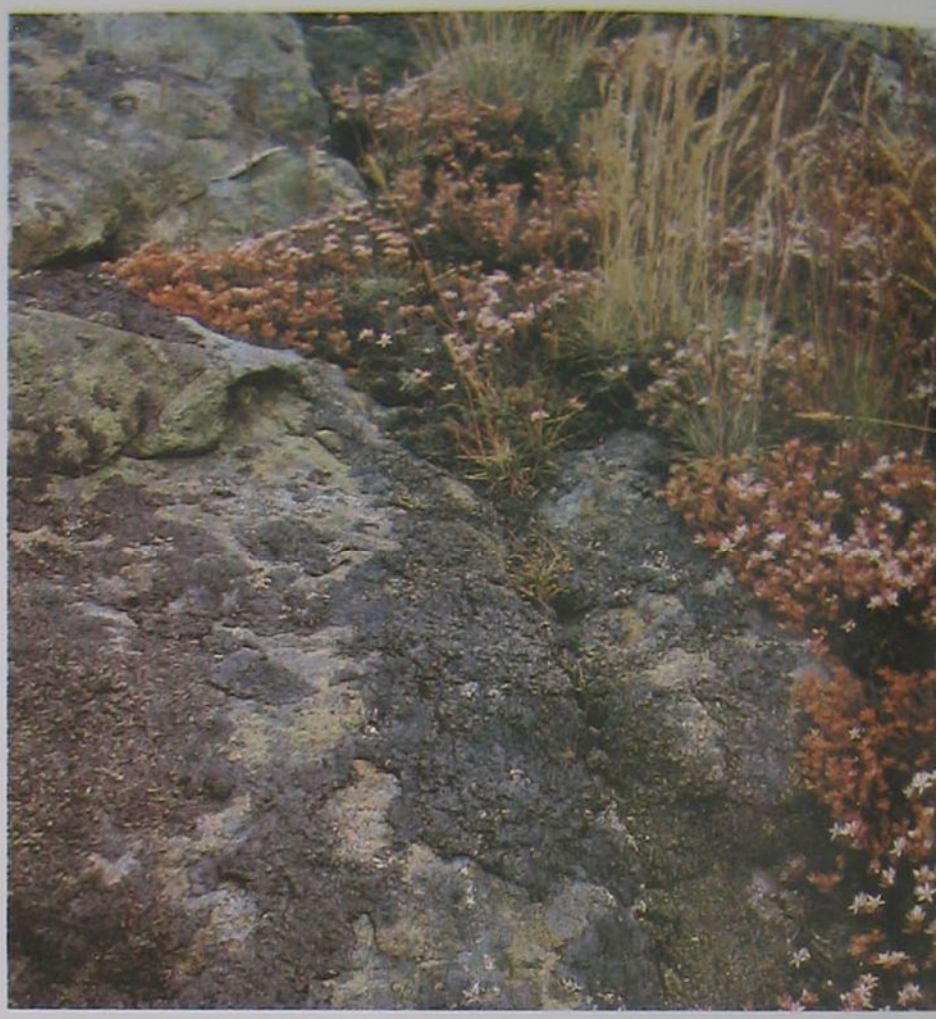
Old walls, scree slopes and rocky coastlines are all dry drought-prone places, ideal for our many species of brightly coloured stonecrops.

With their fleshy stems and leaves and their often tightly packed heads of flowers, stonecrops are one of the most easily recognised groups of plants in Britain. All are members of the Crassulaceae family, representatives of which are found throughout the world, the greatest diversity of species occurring in the hot dry areas of South Africa.

The characteristically fleshy stems and leaves of the stonecrops enable them to endure long periods of drought by storing supplies of water in their tissues. British species are, of course, not so subjected to severe drought as their African relatives, but nevertheless the typical habitats for our species are places prone to periodic drying out: walls, banks, rocks, screes and so forth.

Biting stonecrop Most British stonecrops belong to the one genus, *Sedum*, including the most common British species, biting stonecrop (*Sedum acre*). This plant grows throughout the country, particularly favouring old walls. It is perennial, producing short creeping stems bearing small round fleshy leaves. Both leaves and stems have a very bitter taste which leaves a burning sensation in the mouth, hence its alternative common name of wall-pepper. The juice can also cause blisters and soreness to the skin, and so the plants should be handled with caution.

Biting stonecrop blooms during June and July, bearing clusters of bright yellow flowers on erect leafy flowering stems. The flowers are typical, in both shape and colour, of plants in the genus. There are five green sepals and five yellow petals, all lance shaped and spread out to form a star. Within are ten stamens arranged in two whorls, those of the outer whorl being positioned opposite the sepals and those of the inner whorl being opposite the petals. The stamens of the outer whorl mature first, and after shedding their pollen they curve backwards and the pollen from the inner whorl is released. After fertilisation each flower forms into five follicles–dry fruits that split along one side to release numerous seeds. These are dispersed by wind, their small size allowing them to be blown high up into crevices of walls and other habitats suitable for germination.

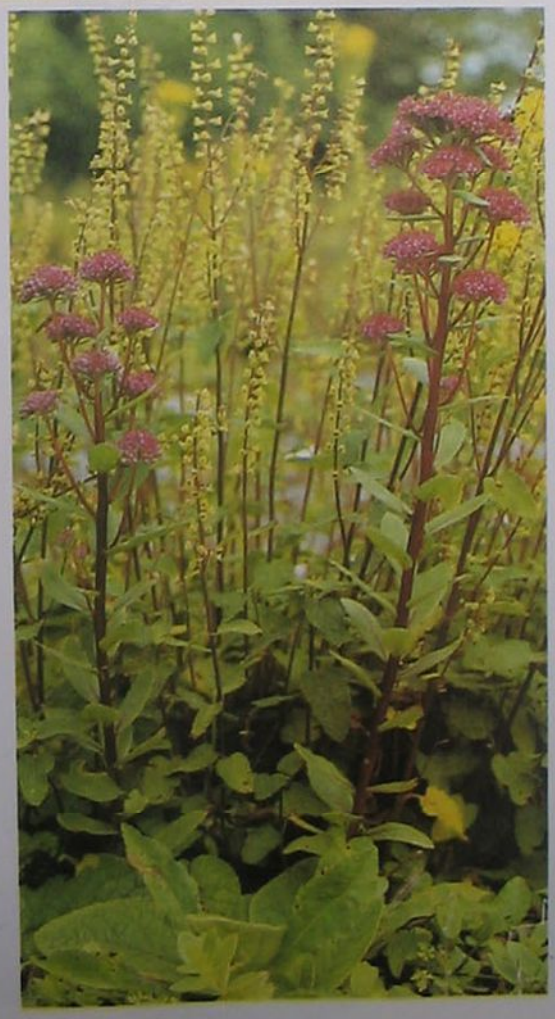


Yellow-flowered introductions Four other species of *Sedum* with yellow flowers grow in Britain, two of which are native and two introduced from abroad and now naturalised here.

The two introductions are insipid stonecrop (*Sedum sexangulare*) and reflexed stonecrop (*Sedum reflexum*). Insipid stonecrop is native to many countries of Europe and is found on old stone walls in a few areas of England and

Above: Like most of its relatives, English stonecrop is a low-growing perennial plant that forms a mat of short creeping stems. This species grows over rocks, sand dunes and dry grassland, rarely being more than 5cm (2in) tall. It is not confined solely to England, despite its name.

Right: One of the commonest species of *Sedum* grown in gardens is orpine, also known as livelong. The second name is easily understood by the fact that the plant remains fresh for a long time after being picked because of the large amount of water stored in the stems and leaves. The name 'orpine' is rather more unlikely, however, for it comes from an Old French word meaning 'pigment of gold'. The name was probably originally applied to the yellow-flowered stonecrops such as wall-pepper.



Far right: A flowering head of white stonecrop. The flower structure so typical of *Sedum* can be clearly seen here: the five lance-shaped petals and ten stamens (in this species tipped with black anthers), all surrounding a group of five carpels which will develop into the fruits.

Left: Biting stonecrop, or wall-pepper, has the same flower structure as the white stonecrop, though its flowers are a more typical yellow.

Wales. It looks very similar to biting stonecrop, though its flowers are a little smaller. The surest way to tell the two species apart is to taste them: insipid stonecrop completely lacks the bitter taste of biting stonecrop. Take care, though, in case the plant turns out to be biting stonecrop!

Reflexed stonecrop is commonly cultivated in gardens as well as being naturalised in Britain. It is a far larger, more robust plant than the stonecrops already mentioned, its flowering stems growing to a height of 30cm (1ft) or more and bearing large, bright yellow flowers. The leaves on the flowering stems sometimes curve backwards, especially the ones towards the base, a feature that gives this plant its name.

Yellow-flowered natives The species most likely to be confused with reflexed stonecrop is rock stonecrop (*Sedum forsteranum*), a native species, though much rarer than the former, being restricted to a few counties mainly in the south-west of Britain. To tell the two apart you need to examine the plants carefully. In general, rock stonecrop is less robust and the leaves at the ends of its non-flowering stems tend to be arranged closer together, forming small tufts, whereas reflexed stonecrop has its leaves spread evenly along the length of the shoot.

The botanical name of the stonecrops is derived from the Latin word *sedeo*, meaning to squat–a reference to their typically flat spreading stems. Our other yellow-flowered native species is, therefore, unusual in having erect stems. This plant is rose-root (*Sedum rosea*) also known as midsummer-hen. It is most often seen in mountainous areas of Scotland, Wales and Ireland, where its thick stock grows deep into the crevices of rocks, making it very difficult to dislodge. It also grows on sea cliffs.

Other sedums The remaining British sedums have white or pink flowers. One pink-flowered species with erect habit similar to that of rose-root is orpine or livelong (*Sedum telephium*). This is the tallest British sedum, reaching up to 60cm (2ft) high. It is found in most parts of Britain in woods and hedgerows, though it sometimes occurs as an

escape from gardens and is not truly native.

English stonecrop (*Sedum anglicum*) forms spreading mats over rocks, sand dunes and, occasionally, dry grassland. The leaves and stems are often tinged with red, as too are the white flowers, each petal being flushed with pink on the back. White stonecrop (*Sedum album*) and thick-leaved stonecrop (*Sedum dasyphyllum*) are both believed to have been introduced here from abroad, and both flower around the same time of year–June and July. Both also have smooth hairless stems, a feature that serves to distinguish them from hairy stonecrop (*Sedum villosum*), which has a covering of short sticky hairs and petals that are a darker pink. Hairy stonecrop is unusual in that it favours wet stony places and stream sides rather than dry sites.

Different genera The remaining British stonecrops all belong to different genera to *Sedum*. Houseleek (*Sempervivum tectorum*) is placed in a different genus because its leaves are arranged in a rosette at the base of the plant and there are a greater number of petals, usually ten to twelve. The basal rosette of thick fleshy leaves endures for several years, during which time the plant reproduces itself vegetatively by forming runners bearing plantlets at the end. Eventually the parent plant flowers and then dies.

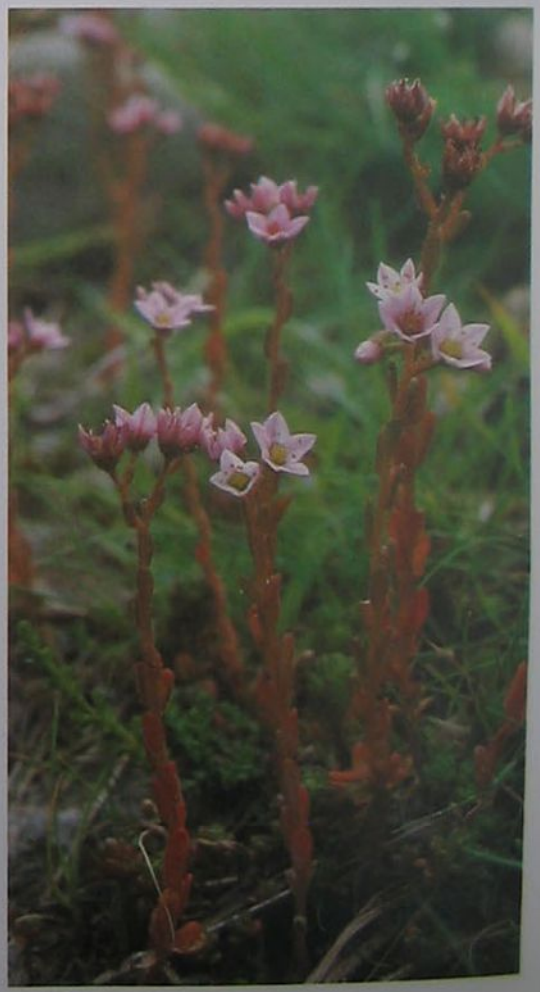
The family name, Crassulaceae, comes from a genus called *Crassula*, of which there is one native member in the British flora. This is mossy stonecrop (*Crassula tillaea*), a plant looking rather like a miniature version of a *Sedum* species. It is a ground-hugging plant with fleshy leaves that are green at first and then turn red. The flowers are white and minute, with three petals and three sepals. A fairly rare plant of southern England, it is found on sandy grasslands and on gravelly ground on heaths.

The remaining member of the Crassulaceae common in Britain is the pennywort (*Umbilicus rupestris*). This plant grows in the crevices of rocks and walls, and is particularly common in the west of England. Pennywort is an unusual-looking plant with fleshy leaves that are more or less circular in outline and attached to their stalks at the centre of the blade. The greenish-yellow flowers look quite different to those of other family members because the petals form a bell-shaped corolla rather like that of a foxglove flower. Nevertheless the flowers have fundamentally the same structure as other stonecrops, with the five petals being fused rather than separate.

Above: The succulent stems of rose-root arise from a very thick root stock that grows into the crevices of mountain rocks. If broken, the stock gives out a pleasant smell that has been likened to the perfume of a damask rose–hence the name rose-root.

Below right: The covering of hairs on the stems and leaves of hairy stonecrop serves to distinguish this species from the otherwise similar white and thick-leaved stonecrops.

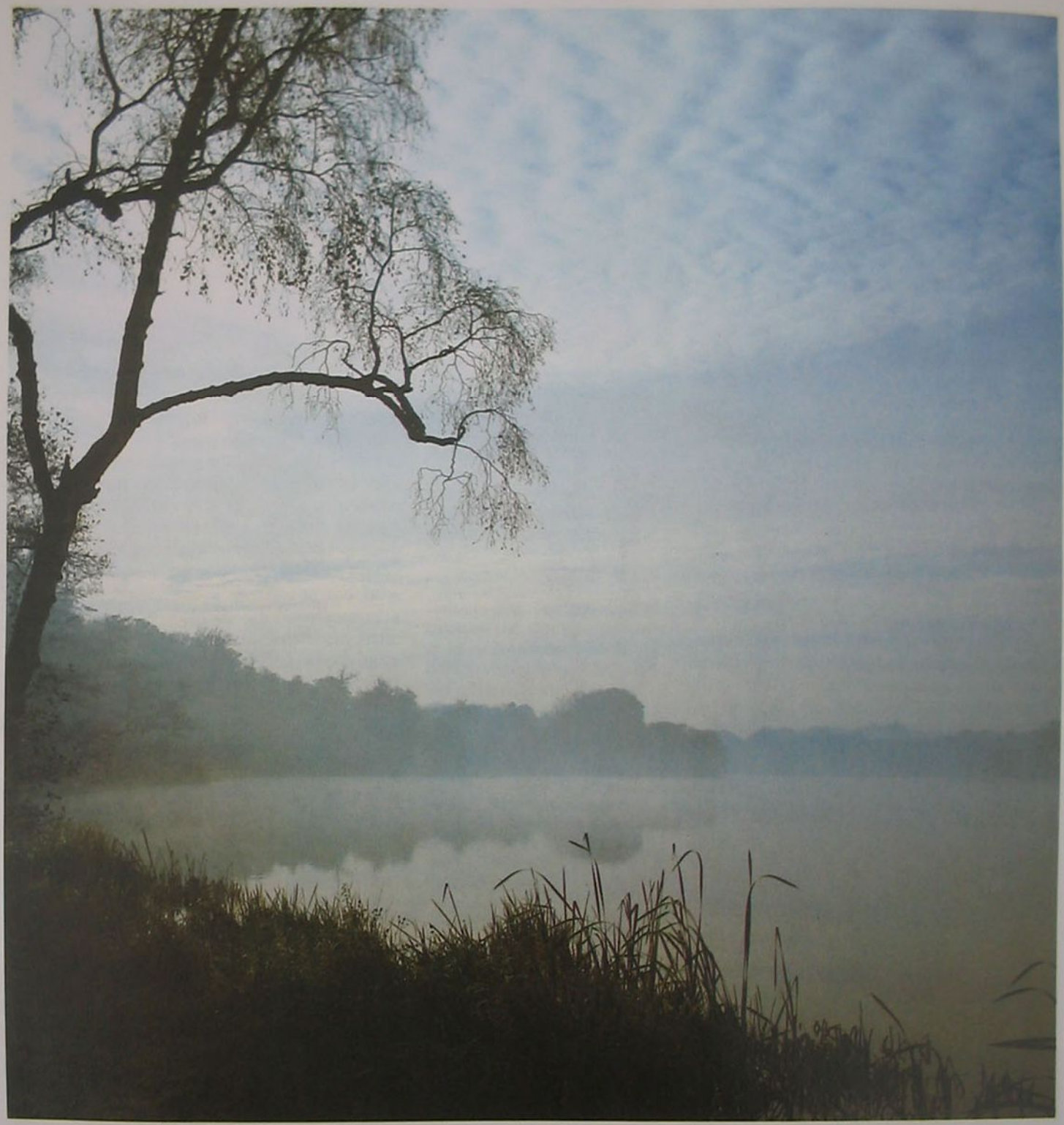
Below: Rock stonecrop, though native, is rare and found in only a few counties in south-west England and Wales, where it grows on rocks and cliffs.



The stonecrop family

British native and naturalised members of the stonecrop family, with insets showing close-ups of the individual flowers. Note the similarity in the flower structures of *Sedum* species, and how the members of the other genera differ.

1 Thick-leaved stonecrop (*Sedum dasyphyllum*).
2 White stonecrop (*Sedum album*).
3 Orpine or **livelong** (*Sedum telephium*).
4 Hairy stonecrop (*Sedum villosum*).
5 Rose-root (*Sedum rosea*).
6 English stonecrop (*Sedum anglicum*).
7 Biting stonecrop or **wall-pepper** (*Sedum acre*).
8 Rock stonecrop (*Sedum forsteranum*).
9 Reflexed stonecrop (*Sedum reflexum*).
10 Mossy stonecrop (*Crassula tillaea*).
11 Pennywort (*Umbilicus rupestris*).
12 Houseleek (*Sempervivum tectorum*).



SUMMER AND WINTER PIPISTRELLES

Contrary to popular belief, pipistrelle bats often emerge on mild winter nights. Paul Racey and Mark Avery describe their pipistrelle investigations.

Above: Virginia Water in Surrey at dawn, a typical pipistrelle habitat. Racey and Avery discovered that pipistrelles only emerged in winter when the temperature was 8°C (46°F) or above. On colder nights they could not catch enough insects to make feeding profitable. From data collected over 350 winter nights they found that on 76% of nights the bats did what was expected, showing that bats are able to choose the most advantageous nights to emerge.

Pipistrelle bats, the commonest British bats, occur throughout the British Isles. Like most of the 15 British bat species, pipistrelles have two types of roosts: a nursery roost which females occupy during summer, and a winter roost or hibernaculum, occupied by bats of both sexes during the colder months when insect food is scarce and when bats may spend long periods with their body temperature close to that of their surroundings.

Summer feeding Female bats arrive at their nursery roosts in spring, and although adult males are not allowed into these maternity wards, leading a solitary existence in summer, young males may be tolerated before they reach puberty. Females give birth in mid-

summer, generally to a single young, but occasionally to twins.

Each night, shortly after sunset, the females leave their roost to forage. They are hungry, since they have not eaten for almost 20 hours. A large colony takes up to an hour to leave the roost and the animals can be heard squeaking as they jostle and push to the exit hole. A single bat often leaves first, a few minutes before the others, who follow in bursts, with up to 40 bats emerging in a 30-second interval, followed by a lull when no bats emerge. This emergence in outbursts may confuse predators such as a waiting cat or owl which will find it difficult to select an individual for attempted capture.

To discover how far the bats travelled on their foraging flights, we caught them in nets as they emerged from the roost, and attached gelatin pill capsules to the fur on their backs with surgical cement. The capsules were filled with a chemiluminescent mixture which glows bright green for a few hours so that the bats look rather like fireflies. The capsule is groomed off the fur by the bats when they return to their roost.

With many helpers looking for these 'fireflies', it is possible to get a good idea where the bats are foraging. We can then return to this area night after night with powerful torches which enable us to catch a glimpse of the reflective tape stuck to the tiny numbered rings we attach to the bats' forearms (under licence from the NCC). We found that pipistrelles prefer to forage around riverside vegetation, whether just above the water or around the deciduous trees growing along the riverbank. In a rich lowland valley in north-east Scotland, the bats travelled up and down the river system, straying from it only to feed around nearby ponds and foraging up to 5km (3 miles) from their roost. By contrast, pipistrelles in an upland area consisting of an island of trees near a small loch in the middle of open moorland could not be so choosy and foraged around all the available trees, not just those around the water.

Above and below: Pipistrelle bats. A male pipistrelle will weigh 6.25g (just under $\frac{1}{4}$oz) at the beginning of October, its fattest time. It then loses weight steadily through the winter until the end of April when it weighs only 3.75g ($\frac{1}{8}$oz). In other words, it loses about a third of its weight during this time by gradually using up its fat reserves as winter progresses. By the end of winter, with fat reserves at their lowest, mortality is at its highest.

Using different colour reflective tape for different individuals we have discovered that pipistrelles often feed at the same time and place each night. By sitting outside a bat roost throughout the night and counting the bats coming and going it is possible to work out the activity patterns of the bats. During pregnancy their nightly feeding lasts from one to five hours and females return to the roost throughout the night after feeding. After birth, the demands of a hungry infant change the pattern of foraging because the mothers return to the roost in the middle of the night to suckle their young. Their second flight coincides with the dawn peak of flying insects.

Independence As soon as the young bats can fly (towards the end of August) the mothers leave the nursery to roost, and their young remain. This unusually early severance (for mammals) of the bond between mothers and young may reduce competition for available food. In addition females look for mates during September since all bats living in temperate latitudes mate in autumn and spermatozoa are stored in the uterus until spring when ovulation occurs and pregnancy follows. Attempts to understand how bats achieve this remarkable feat have directed much of our research; in particular, we wanted to find out how active bats were during the time they stored spermatozoa.

Food in winter During summer it is probably quite easy for bats to find enough to eat, but in winter there are few live insects. So what must bats do to survive? They could avoid the

cold months by migrating to warmer countries–this is what almost all insect-eating birds do (for example, swallows and swifts). In other parts of Europe it has been shown that bats, too, migrate south in autumn and again in spring, but at present we think that British bats stay in this country throughout the winter.

Since insect food is rarely available in winter, bats live on their fat reserves, and pipistrelles become very fat during autumn. They lose weight steadily through the winter as they use up their fat. However, these reserves, important though they are, do not alone keep the bats alive at this time. Like hedgehogs and hamsters, for instance, bats can allow their body temperatures to drop right down to about the same temperature as their surroundings. So instead of around 37°C (98.4°F) a bat in a cold place could have a body temperature of only 5°C (41°F). During this period the bat is said to be in torpor, and bats enter torpor for most of the winter. This prolonged period of torpor is called hibernation.

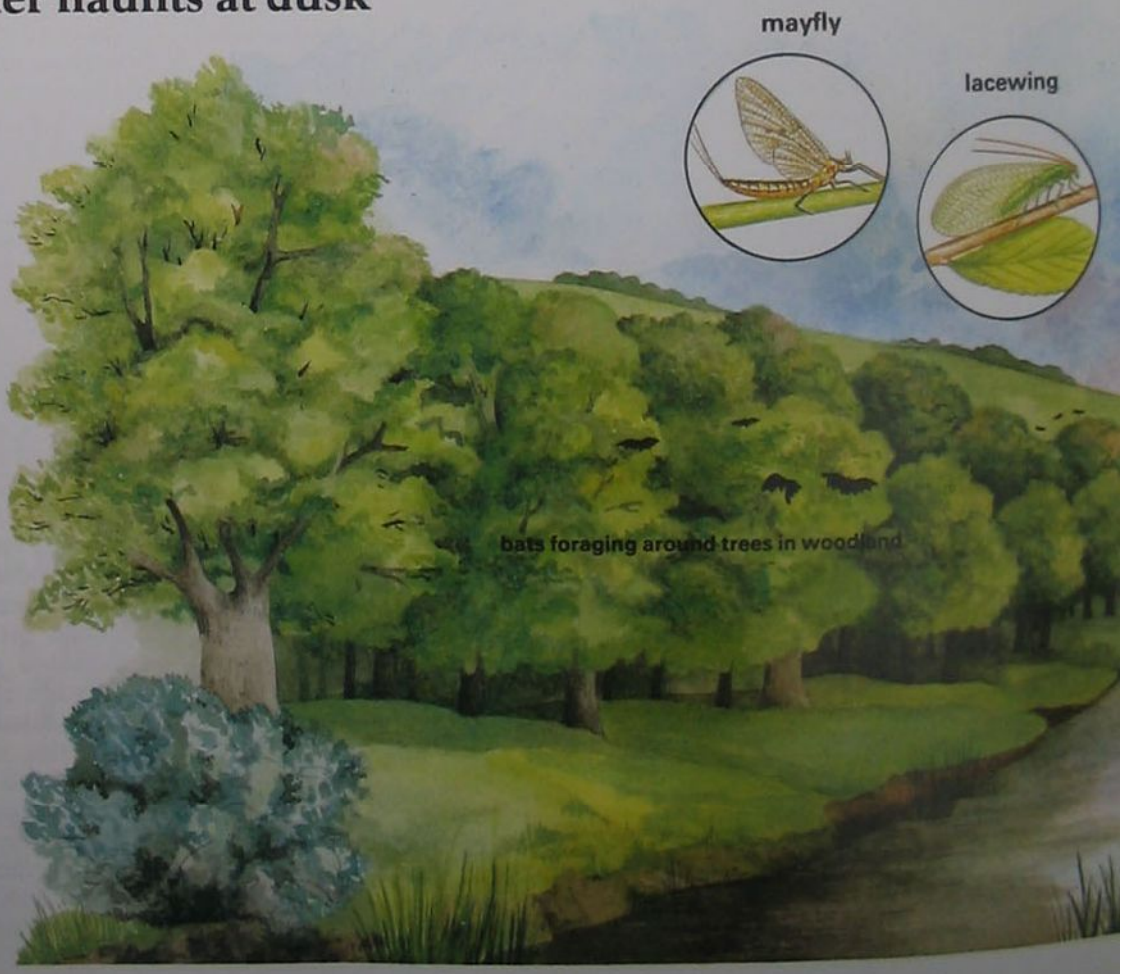
Above: Pipistrelles are crevice seeking bats and make their nursery and winter roosts in narrow spaces. In summer they roost between slates and roofing felt, or between wooden rafters and brickwork. Many bats roost together in these situations–occasionally as many as a thousand in one place. In winter their favourite hibernacula are in medieval country churches in gaps in mortice joints between the beams.

A hibernating bat is vulnerable because at such a low temperature it cannot move, so it must choose a safe place, free from predators, in which to spend the winter. On the other hand, the advantage of hibernation is that the bat uses less energy while it is in torpor than it would if it kept up a high body temperature. This is how bats manage to live on their fat reserves: hibernation allows them to use their stored fat at a slow rate. We still do not know exactly how bats and other hibernators can survive at low temperatures. Certainly it is an ability that man does not have. Hill-walkers who become lost and die of exposure, or old people who die of hypothermia, do so because their body temperature has dropped and they cannot warm themselves up on their own. But this is just what the bat can do; apparently bats can become torpid and then become active again by warming themselves up at any time.

Winter arousal The warming-up process, called arousal, uses up much energy so hibernators arouse in winter comparatively

Pipistrelle summer haunts at dusk

It is dusk, and the bats have emerged to forage for insect food. They fly up and down on a beat for about 20 minutes, catching swarming insects, then they fly directly to another site and establish another beat. Pipistrelles prefer to forage around riverside vegetation just above the water or around the deciduous trees along the river. They take small non-biting midges, caddis flies and lacewings. On nights when there is a hatch of mayflies these are selected. The bats are seldom aggressive to each other, unless the number of flying insects falls when they defend their chosen feeding sites against intruders. If insects are plentiful it is common to see 20 to 30 pipistrelles flying up and down, and never colliding with each other.



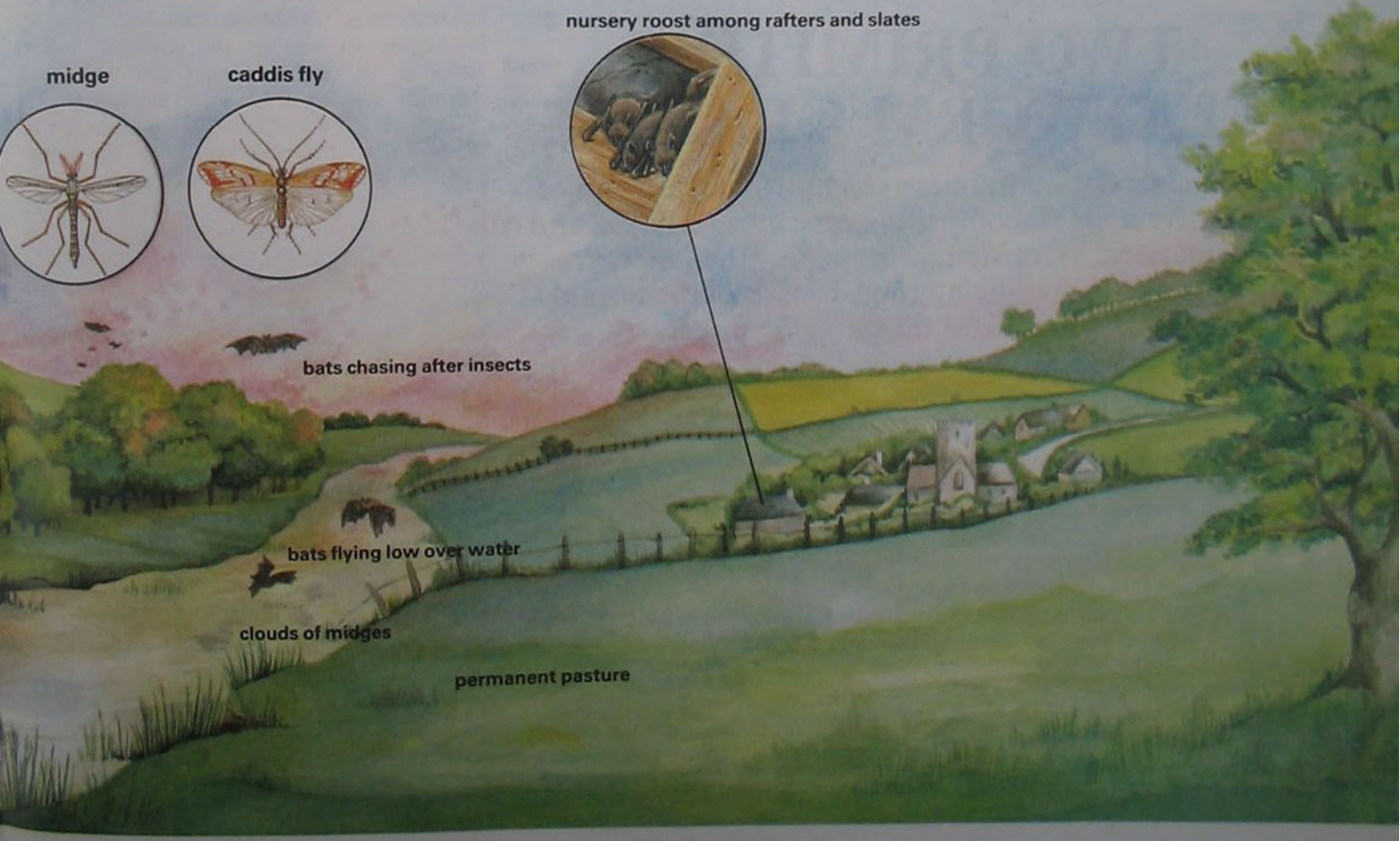
rarely. An undisturbed bat may only arouse once a fortnight through the winter. However, arousal can be triggered if the bat is disturbed, so it is important that the hibernation sites of bats are protected.

Although hibernation and fat storage are the main bat survival strategies for winter, many people have seen bats flying during this time. In the past three winters we studied pipistrelles in East Anglia to find out how often they left their roosts. They were flying outside their roosts on almost half the nights between October and April. Why were they active? And what were they doing?

Using bat detectors we were able to show that the pipistrelles were feeding during the winter nights. The bat detector picked up the very high frequency sounds with which the bats detect insects and it made them audible to us, so allowing us to do two things. Firstly, we could find the bats in the dark by walking around until we heard the characteristic 'pitter-patter' noise from the bat detector. Secondly, we could measure the rate at which bats feed. As a bat dives towards an insect it is about to catch, the 'clicks' of high frequency sound it emits become very close together and sound like a continuous buzz on the bat detector. So by following individual bats we could listen to them through the bat detector to find out if they were feeding or not–we found that they were. We could measure the bats' feeding rate by recording how often we heard feeding buzzes: the warmer the temperature, the more buzzes occurred. Thus we could predict when the bats ought to come out to feed. We collected data for over 350 nights and found that bats were active on warmer nights and stayed in their roosts on colder nights. So our work has shown that, in addition to storing fat and becoming torpid, pipistrelle bats feed in winter. It is worthwhile for them to use energy to forage then because they are able to choose the warmer nights when they are likely to catch most insects.

At a time when steep declines in bat populations are being reported in England it is good to report that there is no evidence of a decline in Scottish populations.

Above: The pipistrelle bat always catches its food in flight. It takes small items directly into its mouth, but larger items may be caught in its very flexible wings. The bat then flicks the food from its wing into the membrane between the back legs from where it takes the food with its mouth. Dawn and dusk are the main feeding times, although a pregnant bat may feed for up to five hours before returning to the roost. Nursing mothers return to suckle the young.



TWO PRIMITIVE FLATWORM CLASSES

The name flatworm refers generally to a phylum of primitive animals comprising tapeworms, flukes and planarians. Here we take a look at the latter two groups–the free-living (non-parasitic) planarian flatworms and the parasitic flukes.

The free-living flatworms, or planarians, are of particular interest to biologists because they show what are considered to be primitive features of multicellular animals. The gut has only a single opening–the mouth. The body has a 'solid' construction in which there is no cavity to suspend the gut or any other organ.

Why they are flat Planarians live in the sea, in fresh water or in damp terrestrial habitats. Since they do not possess any blood vessels for the transport of oxygen, it must therefore enter the body by diffusion, and since diffusion is an inefficient transport process no part of the body may be far from the outer surface. This is one reason why the body is flattened–the larger the flatworm, the flatter it must be.

The second major reason for a flat body lies in the method of locomotion. The underside is covered in a host of little hairs (cilia) which beat in unison to push the worm along, and a flattened shape provides a larger ciliated area per unit of weight, giving more propulsive force.

Some British species Planarians may be black, brown, grey or brightly coloured, and are always associated with water. The most primitive species are all marine, living on or in the substrate. *Procerodes littoralis* lives in freshwater streams on the seashore, under rocks or in tidepools, and can withstand alternate dousing in fresh and salt water.

The best known of British planarians live in fresh water. *Polycelis nigra*, as the name suggests, is usually black, with numerous eyes round the front of the body serving to detect light rather than form precise images. It is widespread in Europe, occurring in all sorts of freshwater habitats. *Dendrocoelum lacteum* is a large, milky white flatworm with two widely spaced eyes, although its colour may be affected by ingested food in the intestine showing through. It is similarly widespread in all freshwater bodies, being particularly common in productive lakes.

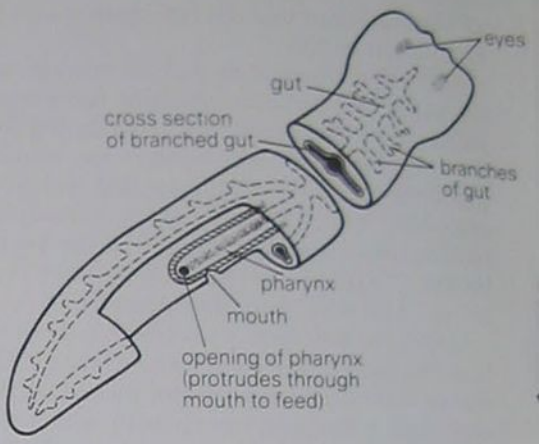
Flatworms in the food chain Almost all planarian species feed on other animals–either as living prey or as carrion. Typical prey items include protozoans, and small invertebrates such as crustaceans, snails and other worms. The mouth is on the underside of the flatworm, not necessarily at the head end, but anywhere along the mid-ventral line, and many flatworms have a pharynx or feeding tube which protrudes to suck in their food.

Flatworms serve as prey themselves for several predators. Freshwater species are preyed on by dragonfly and damselfly nymphs, diving beetle larvae, newts and

Above: This milky white creature is the freshwater planarium *Dendrocoelum lacteum*. Its eyes appear in the photograph as two faint dots, and the branching gut appears as a brown pattern.

Opposite page top: A mass of small planarians of the genus *Convoluta*. These marine animals contain small green unicellular plants, which photosynthesise and provide them with organic compounds. They are commoner on the Continent than on British coasts.

Inside a planarian



'Budding off'

Some freshwater planarian species are capable of breeding asexually. In *Dugesia*, for example, the body narrows near the middle, until the bud-like rear portion breaks off altogether. This develops into a complete new individual, which can then repeat the process. Other planarians may fragment into a number of cysts which each develop into a new individual.

fishes including roach.

Two ways of breeding Flatworms are capable of both sexual and asexual reproduction. Sexual reproduction is remarkably complex for such relatively simple animals. Individual planarians are hermaphrodites, with both male and female reproductive systems, but self-fertilisation is uncommon. Worms form pairs and mate, transferring sperm to one another. Most planarians lay yolky eggs in cocoons, and these hatch as little adults.

When condition are harsh, as in a stream with a poor nutrient supply, planarians reproduce asexually, for this method enables them to increase their populations rapidly with less expenditure of energy. Typically, the rear portion 'buds off' and develops into a new individual.

What is a fluke? Flukes have flat, oval bodies and most are a few centimetres long. Adult flukes inhabit the internal organs or blood vessels, typically of vertebrates and especially of fishes. A well-known British example is the liver fluke, *Fasciola hepatica*, found in the liver of sheep. All flukes have two suckers with which they attach themselves to their hosts. The body wall consists of a thick layer to protect the fluke from the defences of the host, although it must remain permeable to oxygen coming in and nitrogenous waste passing out.

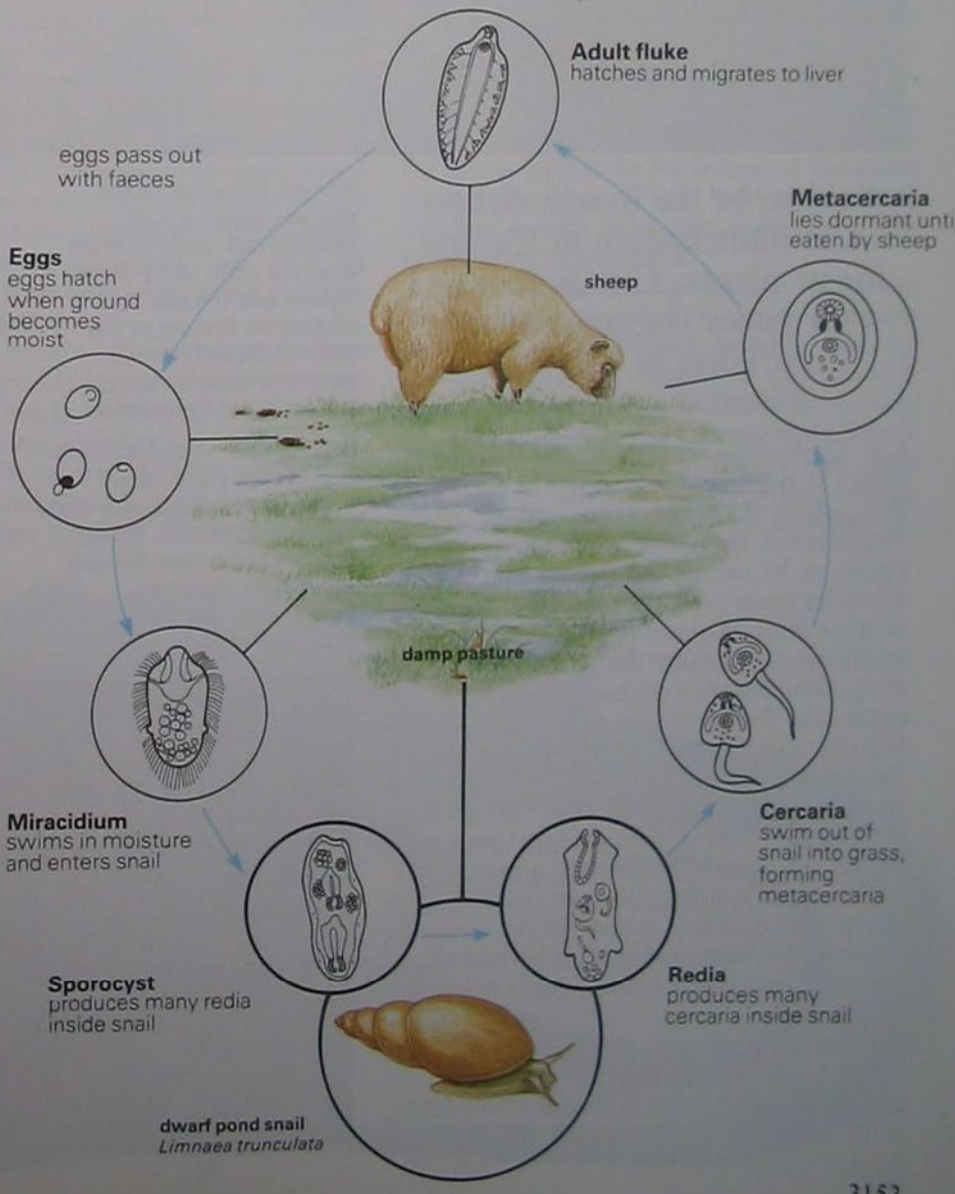
Unlike their tapeworm relatives, which absorb their food through the body surface, flukes have mouths and suck in cells, tissue fluids and sometimes blood from their hosts. They are therefore parasites and are generally harmful to their hosts.

In order to reach new hosts, flukes have remarkable life histories. Since their habitat–the inside of another animal–can only last as long as the host lives, their survival strategy and their whole life-cycle are based on 'migrating' at each stage of the cycle to a new habitat or host. In this way flukes depend on several distinct features of the environment in an interesting way. For the liver fluke, two kinds of animal–a sheep and a snail–as well as damp grassland, are all vital for the continuation of the species.

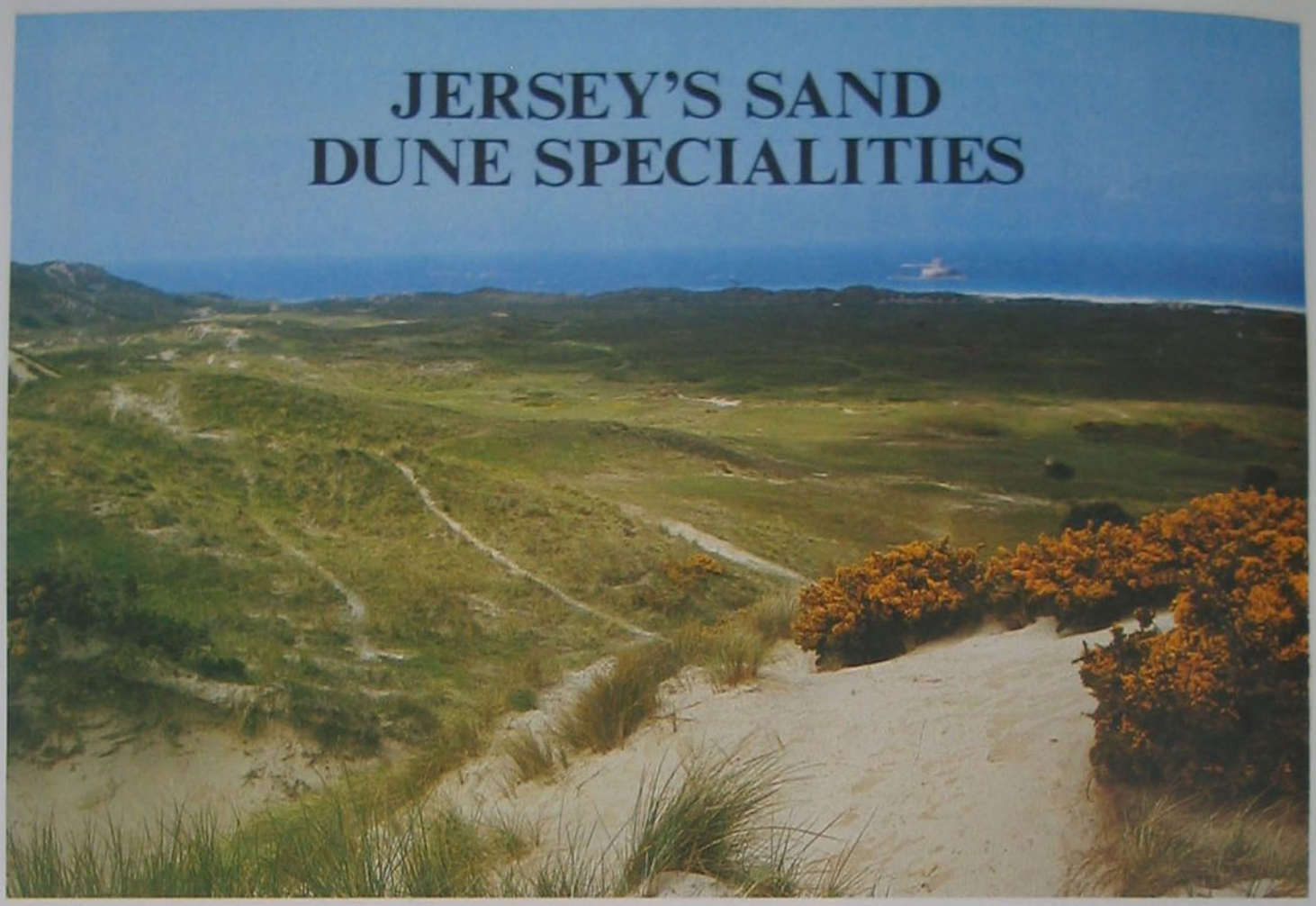
The world of the liver fluke

The liver fluke is a fine example of how parasites overcome the problem of finding new hosts. They spread their successive generations throughout the habitat of their host, and survive by chance encounters with each new host. Another strategy is to produce huge numbers of individuals in certain generations, so that some may find hosts.

The eggs fall to the ground in the faeces of the sheep; each egg hatches into a miracidium, which inhabits damp grass until it chances to infect a snail; the next two stages are located inside the snail; cercaria larvae leave the snail and rest in the grass; when a sheep eats the grass it becomes infected with the fluke, and the cycle begins again.



JERSEY'S SAND DUNE SPECIALITIES



Said to be the fourth richest sand dune system in Europe for its plants, Les Quennevais on Jersey is a naturalists' paradise of rare and fascinating species.

Les Quennevais covers some 100ha (250 acres) at the southern end of the St Ouen's Bay, which is on the west coast of Jersey. Approached from one of the fringing car parks, or by one of the regular bus services along the coast road, the peculiar topography of these dunes is immediately impressive. The small coastal primary dune (the youngest in the system) parallels the beach, but east of the coast road lies an enormous flat plain underlaid by sand, which itself lies on top of Neolithic remains. The 'real' dunes, inland from the plain rather than lying conventionally behind the primary dune, are blown up and over the old granite cliffs. Unlike many systems, there are no wet or even damp depressions, called slacks, trapped between the dunes, so there are no real marsh species except where springs occur below the Golf Course.

Although there are plenty of plants and animals on Les Quennevais familiar to the mainland visitor, what is special about Jersey is its abundance of southern European or Mediterranean species which reach their northern limits on the Channel Islands and only just manage, or fail entirely, to reach the rest of the British Isles lying so much further north. It is an incongruous sight to see these southern species growing alongside our own familiar ones.

Above: The edge of the plateau dunes at Les Quennevais, looking west over the plain to Le Rocco Tower and the sea. A distinctive feature of the plain, especially on its northern side, is the scattering of holm oaks.

Below: The harvest of fruits produced by the many different plants attracts birds like this goldfinch. Other species to be seen include blackbirds, thrushes, bullfinches, tits and greenfinches.

The coastal dunes On the beach only a few species, like the common and frosted oraches (the latter with whitish, mealy leaves) and the succulent sea-rocket, find a foothold in the fine sand. Once on the dunes, sand couch-grass knits the loose material together with its complex root mat, though the dunes themselves are largely the creation of marram grass.

Above: A gatekeeper butterfly. This and many other butterfly species are attracted in particular to the sea holly found at Les Quennevais. In some years there may be an influx of clouded yellows or painted ladies from abroad.

Lizard rarities

The dense grassy cover and network of footpaths at Les Quennevais provide ideal conditions for lizards. Jersey has two species, both essentially south European in distribution and neither native to Britain. The **green lizard** is the larger, at more than 13cm (5in) long, and is a striking bright green. The female tends to be browner, with faint stripes or blotches. The **common wall lizard** is much smaller and grey or brownish, usually with complex conspicuous dark and pale markings. The home ranges of both animals tend to be small.

The number of other plants capable of tolerating the dry, mobile sand and the salt-laden winds are few. Sea-bindweed creeps over the sand surface under the protection of the marram, and sea holly, with its prickly greyish leaves, is also found here.

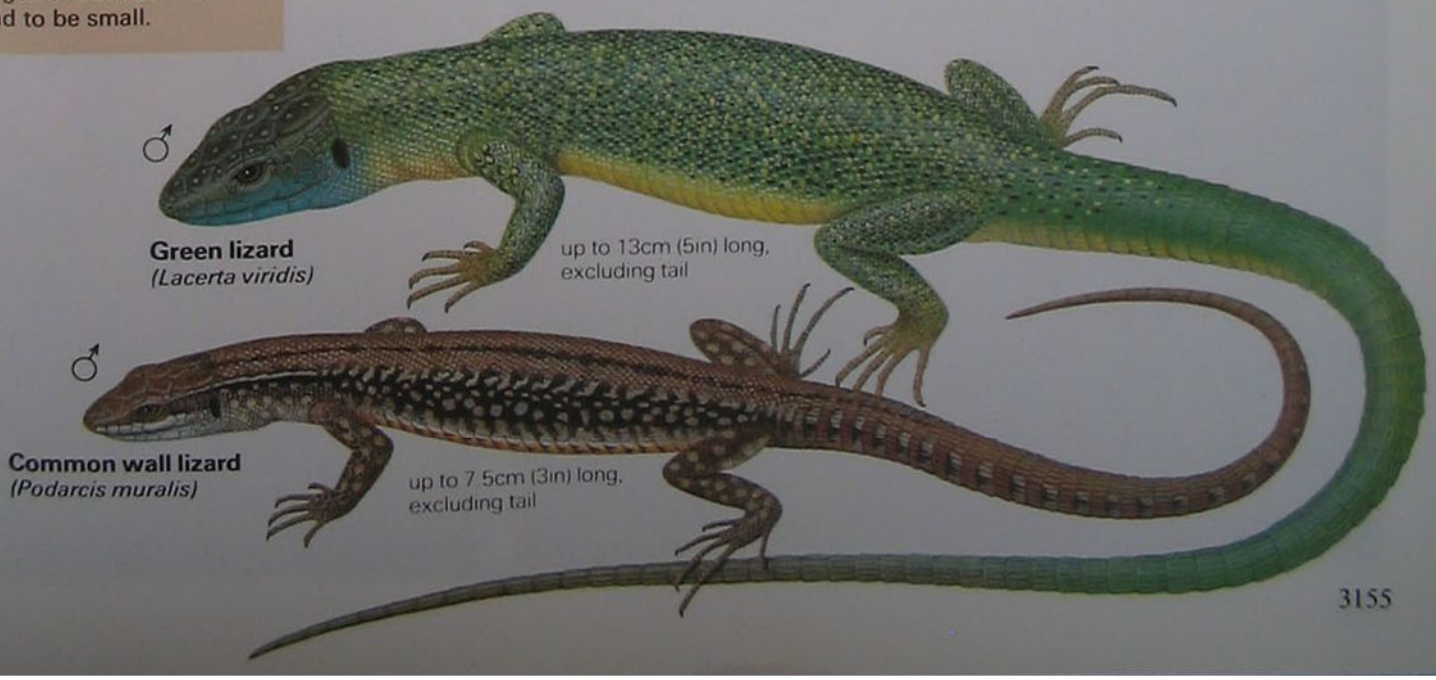
The inland dunes The paucity of species on the coastal dunes is in marked contrast to the situation inland across the coast road. With more shelter, stable sand, a build-up of organic matter in the soil, and less salt spray, the variety of flowers and insects found here becomes prodigious. On the low dunes on the southern edge of the plain, there are extensive areas with a thin vegetative cover, and plenty of space for the winter annuals which are such a feature of this dune system. These are plants which germinate in autumn and winter, flower and set seed early in spring, and avoid the dry summer conditions by lying dormant as seeds. They are mostly tiny and can only be separated one from another by going down on hands and knees.

Two of the more conspicuous species here are grasses: hare's-tail grass, with its soft grey, fluffy fruiting heads, and the greater quaking grass with large pendulous fruits. Both introductions from the Mediterranean, they can also be found (though rarely) in southern or south-western England. These are only a few of the grasses in these very rich areas. Added to these are many other small annuals: rue-leaved saxifrage and thyme-leaved sandwort, both with white flowers; tiny forget-me-nots, the dwarf pansy, (another southern European species), and sand catchfly. The last of these, a rare British plant, has small, dark pink flowers and an inflated, conical green-ribbed calyx.

The key to this great diversity of species is the alkaline shell sand. In such limey, dry, infertile sand, growth is restricted, and so the impact of competition between species is minimal–thus, hundreds of different species can co-exist without a few becoming dominant.

The situation is rather different on the flatter dune plain. Here, leaching of the lime, and the gradual accumulation of dead leaves and their transformation into soil material, has reduced the alkalinity of the soil and increased its fertility. This is particularly noticeable where rabbits are less populous and the level of grazing is too low to maintain an open sward intermingled with small patches of bare sand. Instead, dense grassy areas have developed, especially since the reduction of the rabbit population from myxomatosis. Set in a matrix of the beautiful cream-flowered burnet rose, perennial grasses like hairy-oat grass, sweet vernal grass, red fescue, cock's foot and common bent grow alongside kidney vetch, sand sedge and the slender shoots of wild onion. The richest areas for plants tend to be the fringes of the many small paths where a light level of trampling restricts growth rates and maintains a less competitive environment.

The main dunes Pock-marked with bare sand, the main dunes are a fascinating mixture of blow-outs (collapsed warrens dug by rabbits), stabilising swathes of marram, rich open vegetation and scrub. On the bare sandy areas the early colonizers appear again, which is unusual so far from the sea. Thus, sand couch-grass, sea holly and Portland spurge help to stabilise the mobile sand. However,



away from the worst of the salt spray, the yellow flowers of the fragrant evening primrose provide a dramatic display in early summer.

Among these plateau dunes there are also extensive patches of burnet rose, into which some of the dune annuals have invaded. These signify areas where sand blow from adjacent blow-outs or paths has covered up old surfaces, and only the rose has had the ability to extend up through the deposited material. In some of the blow-outs you can identify two, three or more old dune surfaces which have been repeatedly covered by blowing sand. To some extent, the constantly changing land surface is natural in a dune system, but until a few years ago this was exacerbated by too much trampling and pressure from cars and horses which had open access to much of the plain, and even beyond.

Bees, bugs and butterflies The mass of flowers, warm sand and sheltered hollows provides ideal habitats for a range of small animals. Ground beetles scuttle quickly across the sand in search of prey, while leaf-sucking bugs, ladybirds and other beetles stalk over the plants. On a warm summer's day the air is a cacophony of sound as grasshoppers and crickets advertise for mates; hoverflies dart to and fro between the flowers searching out the nectar or pollen, while pollinating many flowers in passing; and bumble bees buzz heavily, their legs laden with pollen. Sand wasps excavate their burrows in the loose sand, furnishing their larvae with paralysed prey; and butterflies swarm round the flowers. Sea holly seems to attract more than its fair share of butterflies. Common blues (the female browner than the male), small heaths, the larger, orangy-brown gatekeepers, small skippers, peacocks, wall and small tortoiseshells–each appears in its own period throughout the summer.

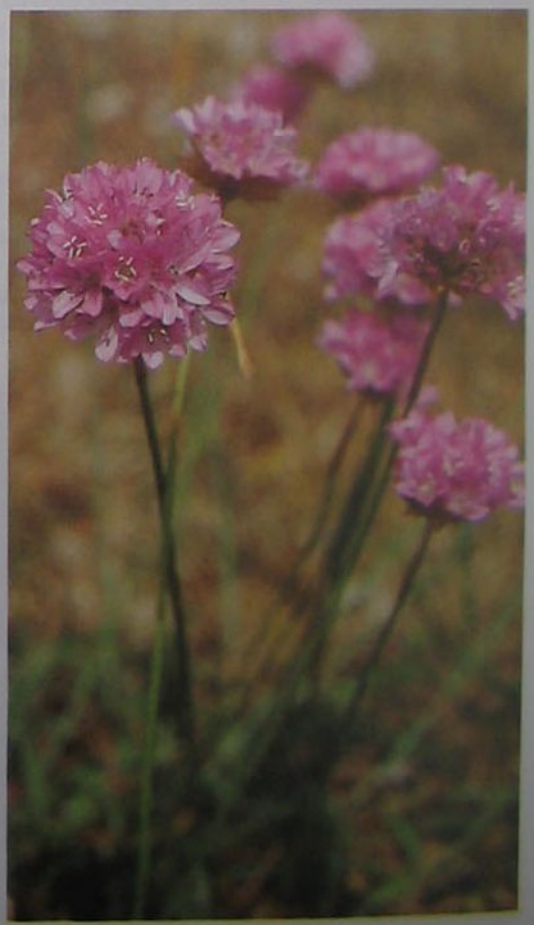
Above: Nottingham catchfly can be seen growing at the edge of the scrubland on the main dunes. A rare plant of restricted English distribution, its perfumed flowers curl back their petals after dusk to attract night-flying moths for pollination.

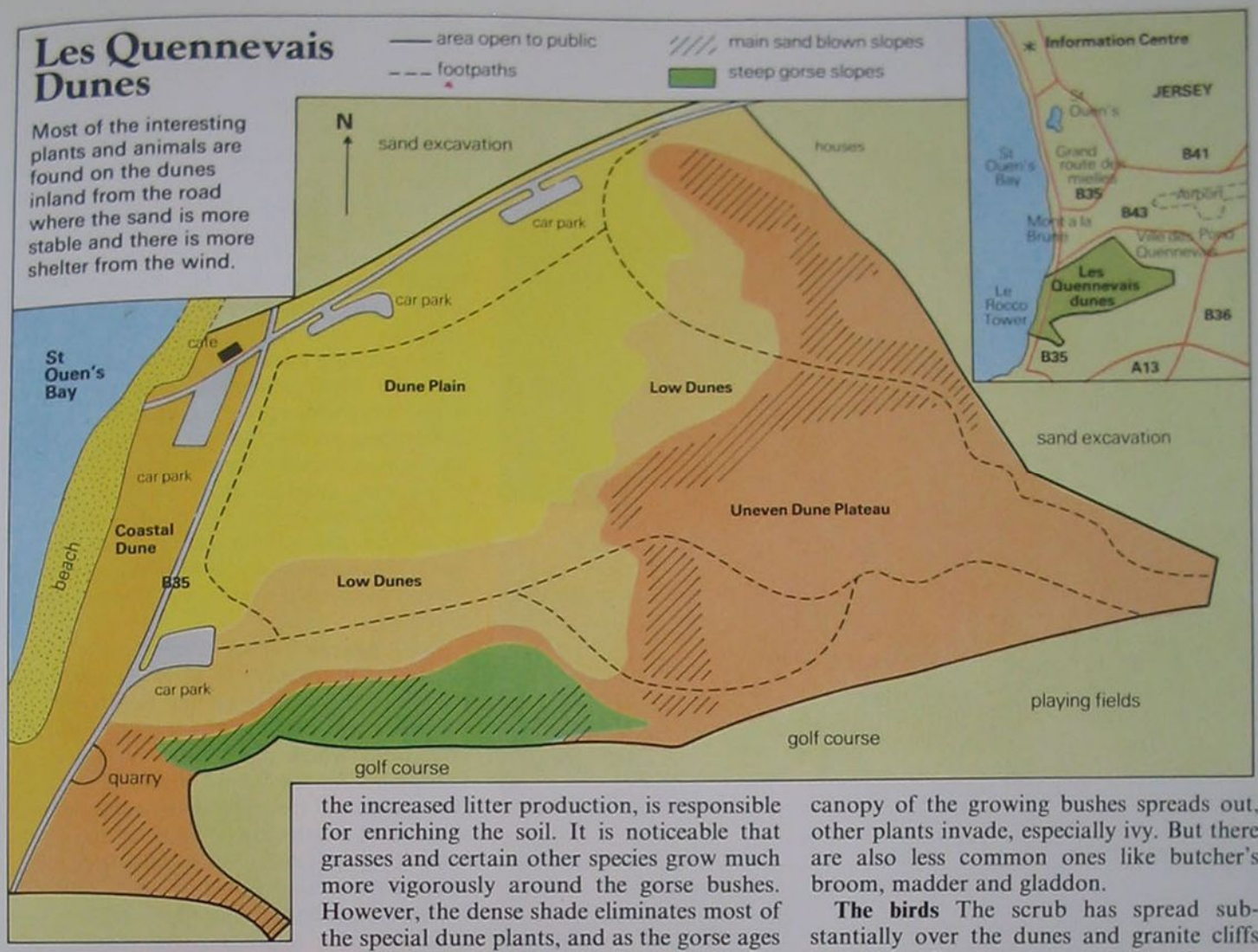
Below right: Jersey thrift (*Armeria arenaria*) in bloom. This plant, a species unique to Jersey, is found on the plain near the small paths which undergo light trampling. It can be seen in company with the childling pink, which like the thrift is of southern European origin, and with the flat greyish rosettes of buck's-horn plantain.

Below: Kestrels can be watched hunting over the dunes and scrubland.

The scrub It may be coincidence, or it may be the result of environmental factors, but it is noticeable that much of the scrub lies on north or north-west facing slopes on the plateau dunes. It is here that leaching would be expected to be higher and exposure to the sun's rays lower. In such circumstances, it is tempting to hypothesise that the acidification of the soil is higher, and species preferring acid conditions, like gorse and bracken, can then invade.

There seems to be a generalised pattern of scrub development (although it does not always follow this progression). First, gorse colonizes the gaps among the grasses. It has nitrogen-fixing bacteria in the nodules on its roots (as do all legumes) and, together with





Above: A map showing some of the main features of the Les Quennevais sand dunes. Some parts of the plain show signs of past disturbance. This can significantly increase the nutrient levels in the soil, and is probably the cause of the taller grasses seen in the hollows and the invading tree lupin and gorse in the vicinity.

the increased litter production, is responsible for enriching the soil. It is noticeable that grasses and certain other species grow much more vigorously around the gorse bushes. However, the dense shade eliminates most of the special dune plants, and as the gorse ages and its canopy opens out other bushes colonize. Nearly all those here–privet, blackthorn, hawthorn, elder and bramble–produce berries eaten by birds which could be roosting or nesting on the gorse, and thus dispersing the seeds in their droppings. As the canopy of the growing bushes spreads out, other plants invade, especially ivy. But there are also less common ones like butcher's broom, madder and gladdon.

The birds The scrub has spread substantially over the dunes and granite cliffs around Les Quennevais over the last 40 years. This has been at the expense of many of the typical sand dune plants, such as the orchids and the annuals, but to the benefit of the birds. The grassy dunes support few birds, skylarks and meadow pipits being the most obvious.

Right: Hare's-tail grass–this grows at Les Quennevais with many other small but distinctive grasses, including sand cat's-tail, hard poa and the very rare, tiny, one-sided flower spikes of early sand grass. Not all the plants on the dunes are rare–also to be seen are lady's bedstraw, wild carrot, restharrow, bird's-foot trefoil, thyme and ribwort plantain.

THE MIGRATION OF INSECTS

Insects, like birds, migrate in response to seasonal changes in climate. There is a difference, however: with birds the northward and southward migrations are obvious, but with insects the return journey is less conspicuous, and only the offspring attempt it.

Many kinds of animals perform migrations, especially those endowed with the power of flight. In its most familiar form migration involves movement over long distances, often hundreds of miles, because of seasonal changes.

Migration with a difference Migration has been most closely studied in birds, some of which escape the rigours of winter by flying south to the tropics, only returning to the temperate regions to breed and pass the summer. It is also performed by some insects, particularly butterflies and moths. There is, however, a difference. In birds the same individual flies north in the spring and south in the autumn, and may continue to do so throughout its life of several years. In insects there is a conspicuous northward migration, mostly early in the year, and a much less obvious southward movement in the autumn. But the insects which fly south are not those which flew north in the spring–it is their offspring.

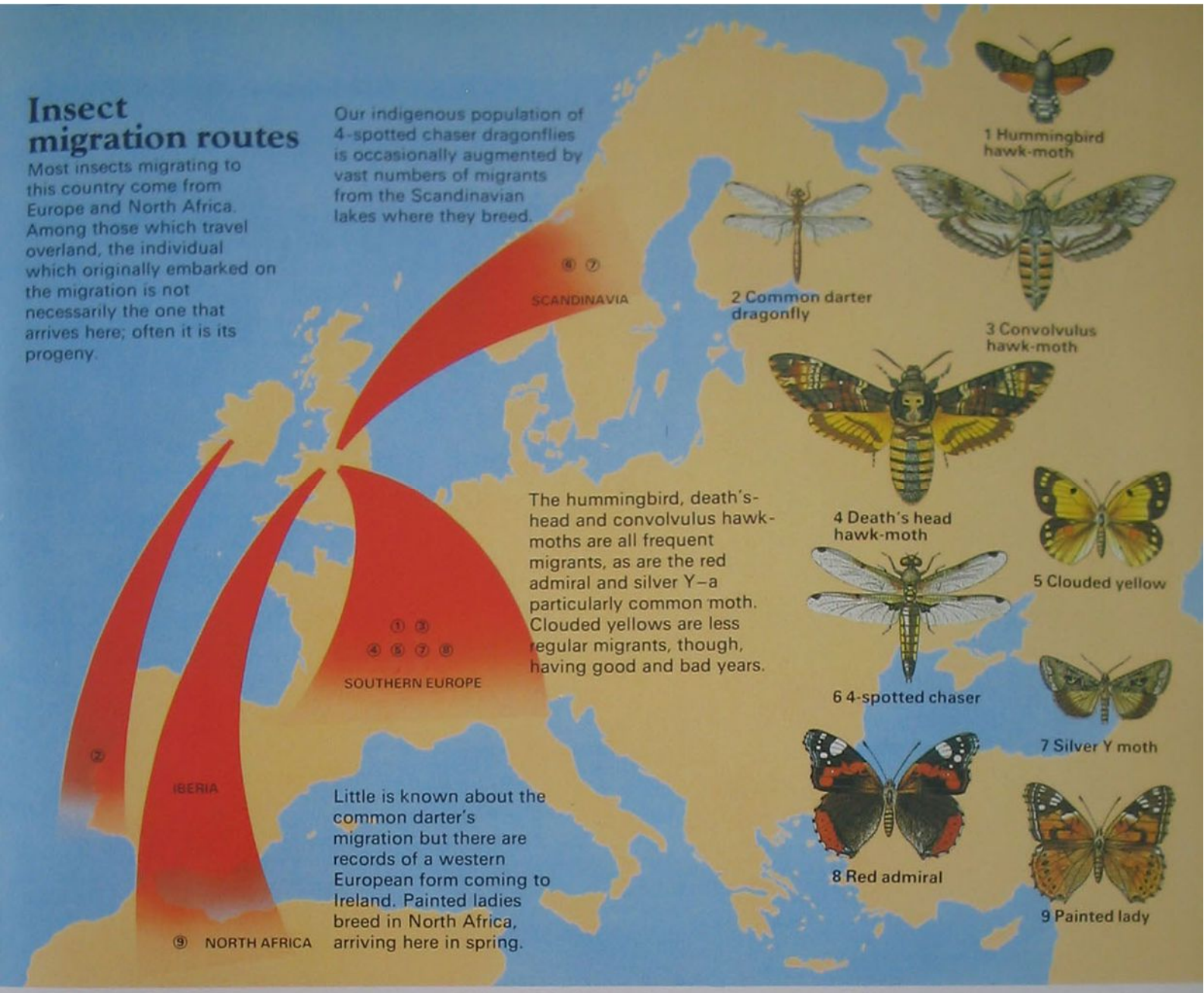
The arriving butterflies and moths, mainly from the Mediterranean region and North Africa, lay their eggs in this country where the larvae feed during the summer and pupate. The winged adults that emerge from these pupae may attempt to fly south to regions where they can breed. Those which fail to do so perish without reproducing. (None of the species performing this kind of migration can survive the British winter in any stage of their life-cycle.)

Why migrate? The chief reason for a northward movement in early summer from the Mediterranean region and North Africa is the onset and northward advance of hot dry conditions which reduce the availability of foodplants for the larvae; in the autumn the increasing cold from the north urges the next generation southward. Added to this is the need for populations to disperse when they become overcrowded.

Butterflies from afar One of the best examples of a migrant is the painted lady butterfly. This species breeds in winter along the desert margins of North Africa and then moves northwards in spring, arriving here in

Above: The convolvulus hawk-moth is a regular visitor to this country.

Right: In September 1947 large numbers of common darter dragonflies were seen arriving on the shores of southern Ireland, but their country of origin was uncertain.



late May or early June. Occasionally earlier migrations are recorded, and the numbers arriving can vary greatly from year to year. The female painted lady lays her eggs on thistles and the larvae feed through the summer, emerging as butterflies in August and September. There is little doubt that this generation attempts to fly south in the autumn, but there is no definite evidence of their arrival in regions which are warm enough for winter breeding.

The clouded yellow (and its two much rarer, pale coloured relatives) performs migrations of the same kind, but much more irregularly, arriving only occasionally in large numbers.

Migrant moths Many migrants exist among the moths. The day-flying hummingbird hawk-moth has a pattern very similar to that of the painted lady: an influx in early summer followed by breeding of one generation. There is some evidence of an autumn southward flight and it also occasionally hibernates as an adult in Britain.

Perhaps our most remarkable migrant is the silver Y, a moth which is generally so abundant in summer that it is hard to believe it is not a resident species. It often migrates in huge swarms. These have been seen mostly at night, flying in various directions, but flights are mainly northward from May to July and southward from late August to October.

The white speck (or American wainscot) is an irregular migrant to the south coast of England. It never arrives in large numbers, although it may be very precariously resident in Devon and Cornwall. Specimens that arrive here appear to be of subtropical American

Below: The painted lady butterfly breeds in North Africa and then migrates north, arriving on our shores in May and June. It seems certain that these butterflies attempt to fly south again in the autumn, but as yet no evidence has been obtained of their arrival in warmer regions.

origin and are extending their range in the Old World.

Feeble fliers Some migrant moths are feeble fliers, so they must rely on favourable winds. One such moth is the rush veneer, which has become celebrated among migrant insects for a remarkable observation made by the late Dr Kettlewell in 1960. Tests made on a specimen which he caught near Oxford shortly after the French had conducted nuclear bomb tests in the Sahara showed that the moth was radioactive, due to the presence of a minute particle in its abdomen that could be identified chemically with the explosion. This was positive evidence that this feeble species had actually flown from the Sahara, covering 2500km (1500 miles), in well under a month.

As well as butterflies and moths, dragonflies perform migrations, but they take place rather rarely and without any easily observed seasonal pattern. *Sympetrum flaveolum* and *S. fonscolombei* are two examples, arriving in fair numbers at intervals of years, rather like the clouded yellow butterfly.

Wind power An important factor in all insect migration is the wind, as few insects can maintain an airspeed of more than about 25km (15 miles) per hour. Nevertheless the larger butterflies and the hawk-moths can make headway against a moderate breeze and there is no doubt that they fly deliberately in a chosen direction. South-westerly winds are dominant in Europe and most migrating insects are carried or assisted by them on their way to our shores. They may sometimes be carried out over the Atlantic from their southern homes and back to Britain by the swirl of wind around an anticyclone.

Vagrant insects A large number of insect species are represented in Britain by only a very few records. Known as vagrants, these

Above: The clouded yellow is an irregular migrant, and can arrive in large numbers. 1983 was a particularly good year for seeing this species in Britain.

Above left: Some insects arrive in Britain by accident rather than on account of any regular pattern of migration. One such example is the very rare oleander hawk-moth.

Below: The vestal moth is a migrant to southern England, where in warm summers it may breed. Among the British-bred moths there is much colour variation and greyish or pink specimens (below) are not uncommon. It is likely that our cooler climate induces these variations.

are chance visitors from the Continent, windborne to our shores by accident.

One such vagrant is the Camberwell beauty, a butterfly which is occasionally carried over the North Sea by easterly winds from northern Europe. It is a great rarity in Britain and is probably unable to become resident in our islands because the winters are not cold enough to keep the butterflies in the state of hibernation essential for their well-being.

Aerial plankton A class of aerial travel which could be regarded either as migration, since it takes place regularly, or as a mere vagrancy is the wide dispersal of small insects carried up in thermals, and then blown, often hundreds of miles, by high level winds, finally coming to earth far away from their homes.

Winged aphids are carried in this way and consequently many species have a circumglobal distribution all around the Northern or Southern Hemisphere or the tropics, living wherever climate and suitable foodplants are available. Insects carried in this way are said to constitute the aerial plankton.

THE BEETLE ORDER IN BRITAIN

With some 350,000 species known to science, beetles form the largest order in the Animal Kingdom. They have managed to colonize almost every conceivable type of habitat, and display considerable variation in shape, size and colour.

Above: One of our more unusual-looking beetles is the glow worm (*Lampyris noctiluca*). This species and one other almost extinct beetle, *Phosphaenus hemipterus*, are the only beetles that communicate by emitting light.

Right: The Endomychidae is principally a tropical family but six species occur in Britain, one of which, the fungus beetle (*Endomychus coccineus*), is found in fungi and rotting wood.

The beetle order's scientific name, Coleoptera, reflects their most distinctive feature: a main pair of forewings which are specially hardened to form protective covers (elytra) for the underwings which they use for flying. (In Greek *coleos* means sheath and *ptera*, wings.) A vast order, it is impossible to mention every beetle species, or even every family in Britain, but in placing them in perspective we examine the families you are most likely to come across and their distinguishing characteristics.

Predatory beetles Probably the most successful beetle family in Britain is the rove beetles (Staphylinidae). About 1000 species in this family exist as carnivores or scavengers and they occur in habitats as wide ranging as flowers, decaying organic matter and the nests of ants. They are characterised by their elongated shape and short waistcoat-like elytra, and exhibit extraordinary extremes of size: the black devil's coach-horse measures 3cm (1in) in length, while at the other extreme there are the minute species which occasionally blunder into our eyes on hot summer days. The mild irritation ensuing from such intrusions is the result of a defensive ploy used by all rove beetles–the emission of a caustic fluid from their anal glands.

Closely related to the rove beetles are the carrion-feeding sexton beetles and burying beetles (Silphidae). These large beetles excavate the soil beneath mammal, bird and reptile carcases until the latter are completely buried, at the same time chewing and moulding the flesh into a more manageable shape.

The most completely predatory family in Britain, however, is the ground beetles (Carabidae), a mainly nocturnal group which includes the attractive (and diurnal) tiger beetles. A number of carabids, such as the handsome green or bronze *Calosoma inquisitor*, perform a useful service to forestry by consuming defoliating moth and sawfly larvae. Most, though, hunt on the ground–as their name suggests. Ladybirds (Coccinellidae) are also an almost exclusively predatory family, with most of the 45 British species (both adults and larvae) subsisting on aphids and scale insects.

Flower beetles Many beetles visit flowers during summer days, where they feed either on nectar and pollen or on other small insects. They include soldier beetles (Cantharidae), and the blood-red cardinal beetles (Pyrochroidae). *Pyrochroa serraticornis* and *P. coccinea* are the most widespread cardinal beetles and can be recognised by their antennae which are prominently serrated on the inner surface.

Beetles which browse on vegetation are typified by the leaf-beetles (Chrysomelidae). A large family, both the larvae and the adults are vegetarian, many of the latter being iridescent and brightly coloured. Included in this group are the powerful jumping flea beetles and such species as the black bloody-

Above: Soldier beetles, such as this pair of *Cantharis rustica*, occur on flowers and vegetation.

Left: A pair of longhorn beetles, *Strangalia maculatum*, feeding and mating. Longhorn beetles are found in mixed woodland where they feed on nectar, tree sap and other similar liquids, and leaves.

Below: A male stag beetle, *Lucanus cervus*, displaying his rather daunting antlers. The males use these for sparring in the presence of the females–which possess no such weapons.

nosed beetle which, when touched, exudes droplets of scarlet fluid from its mouth.

World-wide pests The most numerous beetle family in the world–and possibly the least welcome–is the weevil family (Curculionidae), represented in Britain by some 500 species. Their elongated rostrums (snouts) make them an easily identifiable group. Some weevils have the habit of feigning death by curling up and dropping to the ground when threatened.

Click beetles (Elateridae) react in a similar way to danger but they are also capable of jumping while lying on their backs; an action achieved by means of a special peg on the underside of the thorax which slips over a catch. The wireworm larvae of some click beetles are root-feeding pests.

Horns and long antennae Stag beetles (Lucanidae) also feast on rotten wood. Although only three species exist in Britain, they are a spectacular group, for the males of most species have horn-like jaws.

In common with stag beetles, longhorn beetles (Cerambycidae) occur most frequently in mixed woodland where they feed on nectar, tree sap and leaves. They are a large family, mostly oblong in shape, but their most remarkable feature is the possession, by some males, of antennae four times the length of their bodies. Many species are serious pests of timber.

Also regarded as economically significant are the wood-borers, the Anobiidae and Scolytidae. The most familiar species in the Anobiidae are the woodworm beetles, which damage wooden furniture, and the deathwatch beetles, pests of large old oak timbers. The Scolytidae have gained notoriety through the elm bark beetle, which was responsible for the spread of Dutch elm disease.

Diverse feeders Two families of beetles (the Geotrupidae and Scarabaeidae) perform a most useful, if unusual service: the devouring of dung. Among the Geotrupidae the bulky dor beetle is probably the most familiar species. As consumers of stored foods, members of the Dermestidae are not so useful though. The museum beetle (*Anthrenus museorum*) and the bacon beetle (*Dermestes lardarius*) are among a number of species which, as larvae, attack woollens, skins and meats and other food products.

All beetles undergo complete metamorphosis, but members of several families exhibit two distinct larval forms (hypermetamorphosis). The oil beetles (Meloidae) are the best exponents of this: their larvae hitch a ride on certain mining bee species and parasitise their eggs, subsequently changing their larval form to become legless and blind.

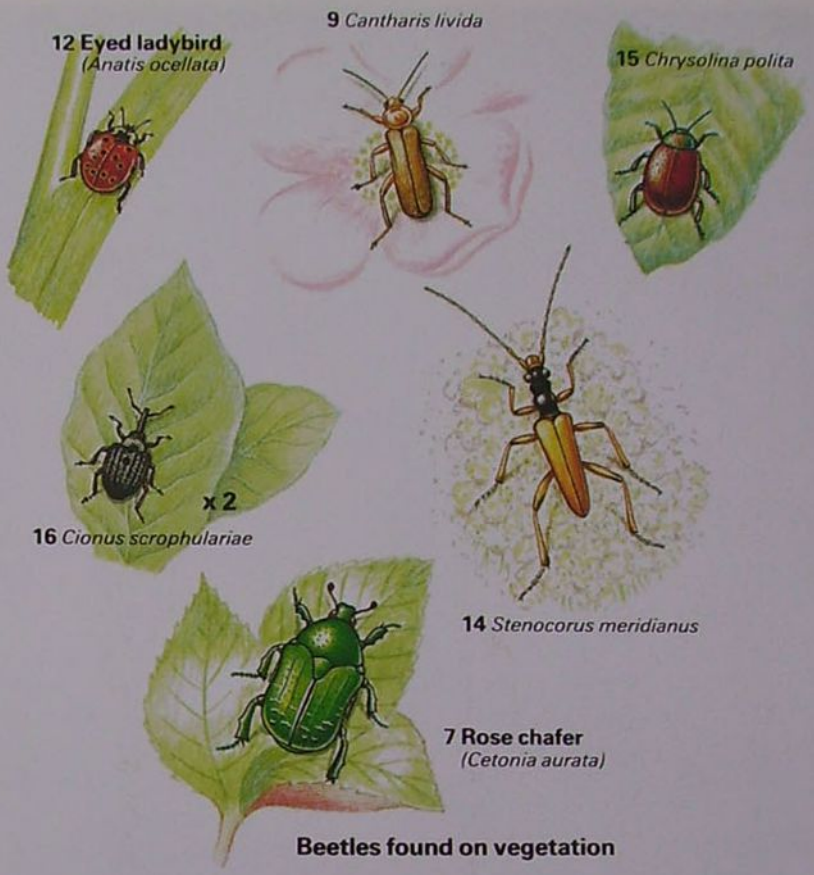
So diverse is the beetle order that a few families have even taken to an aquatic existence. The most frequently seen are the small whirligig beetles (Gyrinidae) which perform seemingly tireless dancing patterns on the surface of ponds and lakes.

Beetle round-up

A total of 3729 beetle species in 96 different families exist in the British Isles. Below is a chart listing some of the commonest families with an illustration of a species from each.

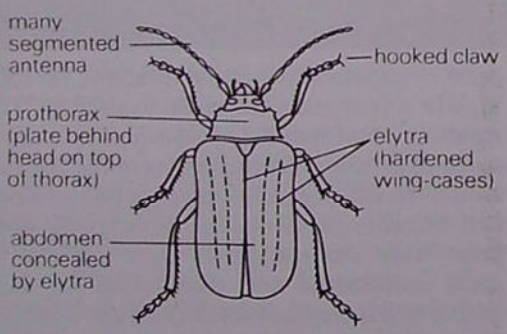
Principal beetle families

Order	Family	No. species
COLEOPTERA	**1** Carabidae	354
	2 Gyrinidae	13
	3 Silphidae	23
	4 Staphylinidae	992
	5 Lucanidae	3
	6 Geotrupidae	8
	7 Scarabaeidae	78
	8 Elateridae	65
	9 Cantharidae	42
	10 Dermestidae	22
	11 Anobiidae	25
	12 Coccinellidae	42
	13 Meloidae	9
	14 Cerambycidae	61
	15 Chrysomelidae	254
	16 Curculionidae	407
	17 Scolytidae	60

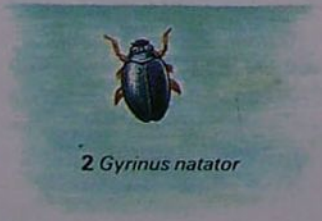


Beetles found on vegetation

Distinctive beetle features

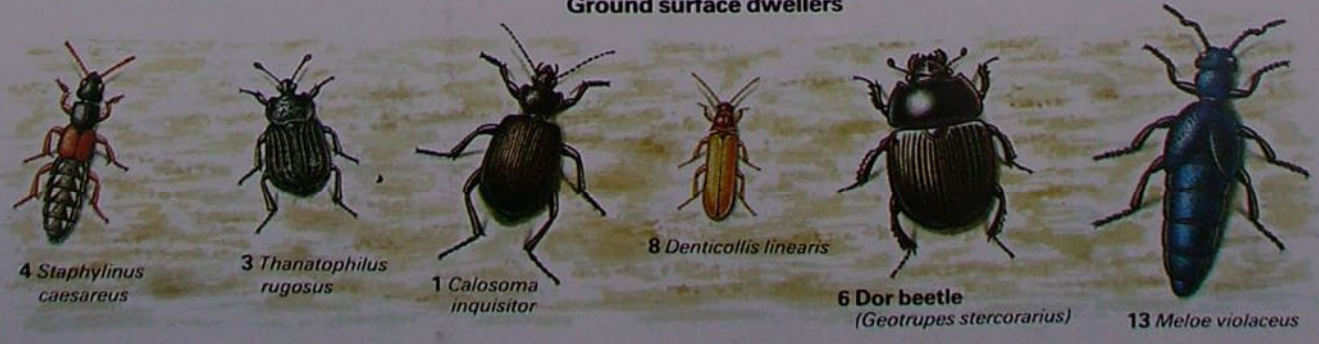


Aquatic species



Beetles occurring on rotting wood

Ground surface dwellers



READING THE SIGNS IN A WOOD

The local wood that you like to walk in of a weekend holds far more clues to its past than you may realise. Once you learn how to decipher these clues you can learn a great deal about the history of the wood and even estimate its age.

Above: A coppice of small-leaved lime with a layer of bluebells underneath. The regular cutting of the coppices–which in this wood last happened eight years ago–allows plenty of sunlight down to the woodland floor. This in turn encourages the bluebells to spread to a degree that would not be possible in an ordinary wood of standard trees (unless the soil was very sandy). The presence of such a carpet of bluebells in ordinary woodland indicates the trees were once coppiced.

Most people assume that our oakwoods, beechwoods and woods of our other native trees are all an old and natural part of the countryside, but this is a long way from the truth. Natural woods, completely untouched by man, no longer exist in Britain. Many of our woods are young, perhaps only a century or two old, and even our older woods were in almost all cases used or managed in past centuries. A great deal can be learned about the history of a wood by looking for signs of past management.

Clues to a coppice One very ancient tradition was to manage a wood as 'coppice with standards'. When shrubs and young trees are cut back to the ground they quickly sprout a head of shoots which grow to about 2m (6ft) high in a year and then begin to thicken. The resulting plant is called a coppice. After about seven to fifteen years the shoots of the coppice used to be cut to yield a supply of poles, staves and brushwood. Scattered through the coppices were the standards–trees allowed to grow unhindered and then felled for their timber when they had reached an age of about 70 to 150 years. The standards were sometimes obtained by a process called singling, which involved cutting out all but one of a clump of coppice shoots. On other occasions the standards were simply planted, oaks often being favoured for this because their branches cork-screw slightly as they grow, thus supplying ready-shaped timbers for shipbuilding.

The most obvious sign of past coppicing is the presence of 'many-trunked' trees growing on the site of old coppice stumps. But there are more subtle indicators. First, it was important in past times to keep out livestock, otherwise they would destroy the young coppice shoots, and so the wood was often surrounded by a ditch with a large bank inside it, which was once fenced. The remains of the bank and ditch can still be seen today in many places.

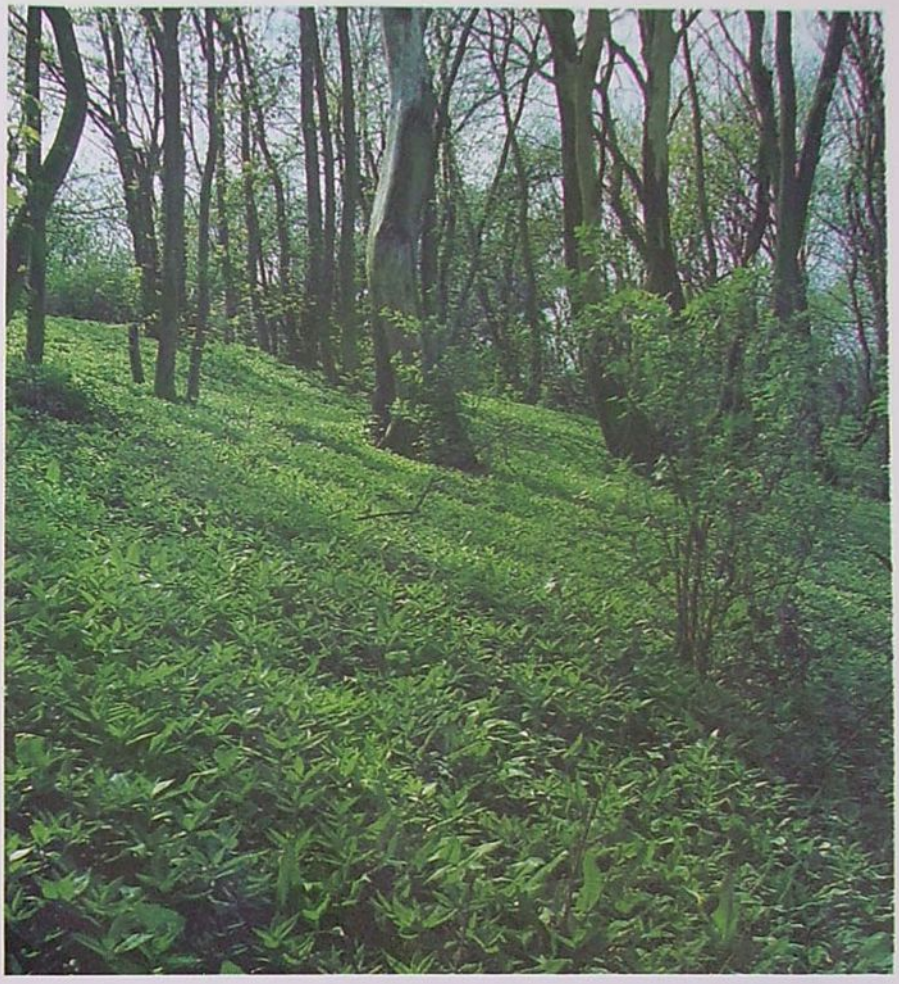
Another important clue to woods that were once coppiced is the abundance of spring flowers. The regular cutting of the coppices allowed plenty of sunlight to reach the floor of the wood, and this encouraged the growth of plants. Some of these plants are normally slow

to spread, or seed poorly, so their presence in large numbers on the woodland floor is an excellent indication that the wood is ancient and was once coppiced. Take, for example, bluebells. They spread only slowly on heavy clay soils, so a carpet of them under trees growing on such a clay soil could be the clue to an old wood, especially if wood anemones and early purple orchids are also present. (Bluebells spread quickly on light soils, however, so beware that the carpet is not picking out a patch of sand in the wood!) In such woods you may find rarities like herb paris, which prefers rather lime-rich soils. Even dog's mercury, which seems to be such a common woodland plant, is in fact rare in recent woodland–that is, woodland that has formed in the last hundred years.

Wild animals, as well as plants, were encouraged by coppicing. The coppice woods were usually divided into compartments, each being cut in rotation. The wildlife could easily move from one compartment to another to find the conditions they preferred. For example, fritillary butterflies, whose caterpillars feed on dog violets, are typical of such woods.

Looking for pollards Another tradition as old as coppicing was to allow livestock to graze the common land of the parish, which often included woodland. In time this wood pasture developed its own appearance: it had a bare grassy floor (for the animals destroyed the spring flowers and the undergrowth) and the trees were well spaced out because the animals also ate many of the new saplings. However, a supply of poles could still be obtained by cropping the branches of the trees at head height, out of reach of the animals, a system known as pollarding. Old pollarded trees can still be seen today, though the technique itself has all but died out, the last true echo being in the Langdale Valley, Cumbria, where the ash trees are still pollarded.

Guessing the age Many of the woods that were once coppiced or pollarded are extremely ancient; indeed they have existed since trees colonized Britain after the last Ice Age. First came the birch and Scots pine, and then, as the climate improved, these early colonizers



Above: Dog's mercury may seem a common woodland plant yet it is rarely found in recently planted woods and so is a good indicator of old woodland.

Right: Another indication of an old wood is a rich variety of flowers, particularly if bluebells, wood anemones and early purple orchids are present. Shown here are wood anemones with primroses.

Below: The Wyre Forest in Shropshire–an ancient oak woodland.

were shaded out by taller broad-leaved trees. The result was a tangled wildwood of oak, ash, elm, alder and lime, together with smaller trees and shrubs such as hazel, hawthorn and holly.

Later, as man arrived, he cleared much of this wildwood leaving only fragments behind which he used for coppicing or pollarding. Other woods used by man for the same purpose may have been 'secondary', growing on ground that had once been cleared but was later on abandoned. In time, however, the secondary wood would have assumed the character of a primary wood and be just as rich in its variety of species–and be just as likely to have been managed by man.

A clue to really ancient woodland is that it contains just native trees and shrubs, and some of them are excellent indicators of this type of wood. Look for Midland hawthorn, which has leaves with blunter lobes than does the common hawthorn and two or three pips in the haw rather than a single one. Small-leaved lime is another good indicator–its leaves are usually about 6cm (2½in) long with tufts of rust-coloured hairs underneath; other limes have larger leaves with white tufts or none at all present.

You will rarely see any of the many species of foreign tree introduced by man in an ancient wood. Even sycamore, which was introduced about four centuries ago and has become widely naturalised, is only found in recently established woods, or in woods that have been neglected this century (as many have).

Plantations and modern woods Even in an old wood the trees may not be as natural to the site as they look. Worries about the supply of timber for the Navy 400 years ago led to the birth of a new kind of wood management quite different to the old coppicing tradition. This was the close planting of trees to create tall trunks for timber. Oak was often chosen, and beech–the beechwoods north of Derby have this rather recent origin. Even the famous Burnham Beeches on the Chilterns grow on what was either open ground or coppice 200 years ago. Since then other plantations have been established: larch and Scots pine during the Victorian era, then foreign conifers during the present century.

The clues to a plantation, whether old or new, are the trees being of one age, of one kind and planted in rows (though in some of the older beech and oak plantations this consistency has been smudged by selective felling in the past).

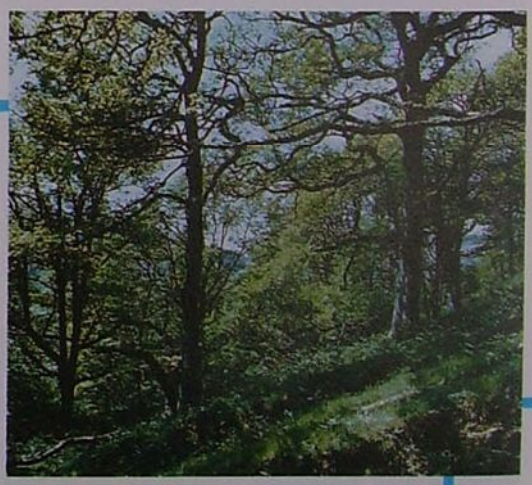
Recent woods Just as the species, age and shapes of the trees, along with the variety of spring flowers, are clues to the wood's history and age, so there are similar clues to recent woods, the ones that are perhaps less than a century old. Ivy did not grow well under coppice management, and it did not survive in grazed woods, so it carpets the ground only of new woods.

Clues to a wood

When you go into a wood the first sign to look for is whether the trees are all of one kind, and about the same size and age, or are there many different kinds.

Trees of many different kinds, with oak probably dominant, indicates an old woodland. All the trees are native though sycamore may have invaded the wood.

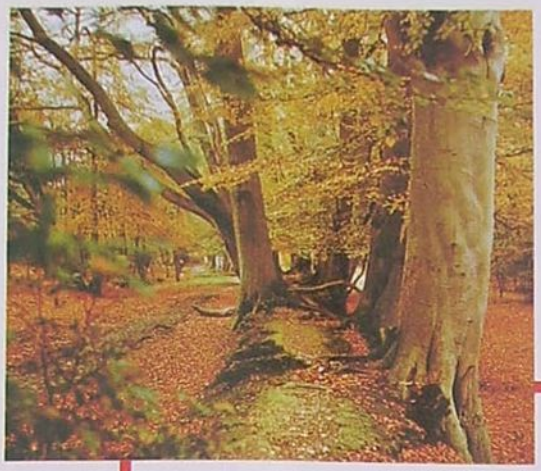
Trees of one kind (such as oak or beech) growing close together with tall trunks, perhaps planted in rows, indicates high forest plantation more than 100 years old.



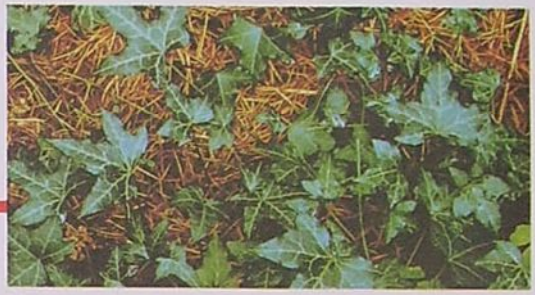
If the woodland is old it was once either coppiced or grazed.

If the wood was once grazed (ie, used as wood pasture) the trees would have been pollarded, not coppiced, for the livestock would have destroyed the young coppice shoots. Therefore look for old pollards and a lack of variety in ground plants as the clues to old wood pasture.

Other features of plantations include rides (often with ditches alongside) and narrow straight boundary banks. These features may, however, have been imposed on older coppiced woodland.



Cow parsley growing strongly beneath trees can indicate secondary woodland growing on what was recently open land.

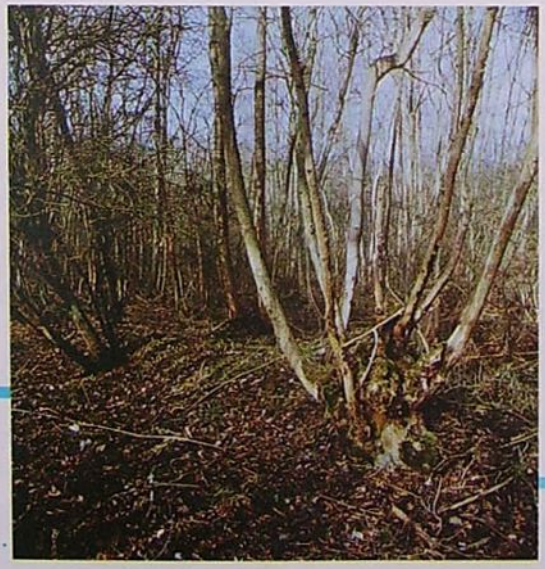


The ground thickly covered with ivy also indicates secondary woodland. Ivy was cleared from older, coppiced woodlands.

Trees all of one kind and age, definitely planted in rows and usually foreign indicates a modern plantation. (Note the Forestry Commission was established in 1913.)

Midland hawthorn (which is not confined to the Midlands) indicates old coppiced woodland that has never been anything but woodland.

Look for signs of previous coppicing; perhaps there are 'many-trunked' trees growing from the site of the old coppice stools. The main point is that a wood that was being coppiced 100 years ago is likely to be an old wood.



Small-leaved lime is another good indicator of an old coppiced wood. Its leaves are noticeably smaller than the common lime.

Look to see if there is nothing but grass under the trees (see left). This suggests that grazing continues. Wood pasture is a dead tradition but some old northern coppice woods are now used for sheltering and grazing sheep.

Look for a great variety of flowers, such as bluebells, wood anemones, herb paris and others. Many different butterflies also suggest ancient coppiced woodland.

THE DUNNOCK: HOW UNLIKE A SPARROW

Dunnocks have a unique territory-sharing system in the breeding season: they often form trios in which two males share one female. These complex social arrangements are among several important features distinguishing dunnocks from true sparrows.

Male and female dunnocks look very alike. Most of the plumage is a warm brown with black streaks, while the head and breast are noticeably grey and the crown, back of the neck and ear coverts are washed with brown.

Dunnocks belong to the insect-eating family of accentors, which accounts for their very sharp bills, contrasting with the stout, seed-cracking bills of true sparrows. Dunnocks inhabit a wide variety of scrub and similar vegetation, and spend most of their time feeding on the ground, never far from thickets to which they can retreat whenever danger threatens. Their ability to occupy a wide variety of habitats which occur commonly in Britain has enabled them to become our second most numerous farmland bird species–they are outnumbered only by blackbirds.

Social life Recent research has shown that the social life of dunnocks is far from ordinary –indeed, it is absorbingly complex. In winter, dunnocks tend to remain in approximately the same areas in which their breeding territories were located during the previous spring. Throughout this range, groups of dunnocks congregate at particularly good feeding areas. When birds do meet at the favoured area, the heaviest birds are dominant over the lighter ones, and since males are heavier than females, the former tend to survive the winter better.

Separate or sharing Both males and females possess territories in the breeding season. When feeding on the ground in dense vegetation it is very difficult to see, and therefore to evict, an unobtrusive intruder, and so intrusions occur frequently. They are in fact so frequent that the minority of male territories are effectively shared, in the full knowledge of the owner. Within this sharing relationship, one bird is dominant over the other: the dominant bird is usually the older of the two.

Pairs and trios During the breeding season, some dunnocks associate in pairs, one male and one female, but others, possibly the majority, form larger groups, usually of three birds. Trios consist of one female and two males, with the two males sharing the same territory. One of the males, usually the older and heavier and called the alpha male, is dominant over the other, called the beta male. The alpha male asserts his authority over the beta male, especially over sexual relations with the female, but the subordinate beta is nevertheless tolerated within the territory and does occasionally manage to copulate with the female, especially later in the breeding season.

Trios occur generally in the best habitats, where the dominant alpha males have large territories. Since the beta male helps in territorial defence, the dominant bird derives some benefit from the beta's presence in a large territory that might otherwise be difficult to secure. This may, at least in part, explain the alpha male's tolerance of his

Above: The dunnock's presence is often betrayed by its call: a piping, often somewhat insistent and vibrant 'tseep' of mournful quality. The song is a thin, high-pitched warbling.

Right: A dunnock nest in a yew hedge: a fairly typical site both for the type of vegetation and for the location. There are usually four or five eggs, and the hen takes sole charge of both nestbuilding and incubation. The pair usually rears two broods in a season.

associate, but the presence of a second male in close proximity to the alpha's mate does present problems.

While it may be helpful to receive assistance with territorial defence, the alpha male must try to ensure that all of his mate's eggs have been fertilised by him and not by the beta male, for he does not want to waste energy feeding someone else's chicks. The alpha male overcomes the danger that his mate may have been fertilised by the beta male in a most intriguing way.

Mating dance Part of the pre-copulatory display of dunnocks involves the female stooping forward, vibrating her wings and tail, fluffing out the feathers around her posterior like a can-can dancer, and exposing her cloaca to the male. At this, the male pecks at the female's cloaca for a minute or two before he copulates. During this pecking, females have sometimes been seen to eject a small fluid droplet which, on microscopic examination, has proved to be a mass of sperm. The male seems to be trying to ensure that the female's sperm store is empty before he copulates, in an attempt to guarantee that only his own sperm is available to fertilise her eggs.

The female encourages the beta male to stay on the territory. When she can get away from the attentions of the dominant bird, she solicits matings from the beta male and this seems to lead to his assistance at a later stage of the breeding cycle. For in trios where the beta male has copulated with the female, the subordinate male helps to feed the nestlings, whereas if the beta male does not mate, then he offers no assistance. Where this assistance is given, broods are more successful than in the absence of any help.

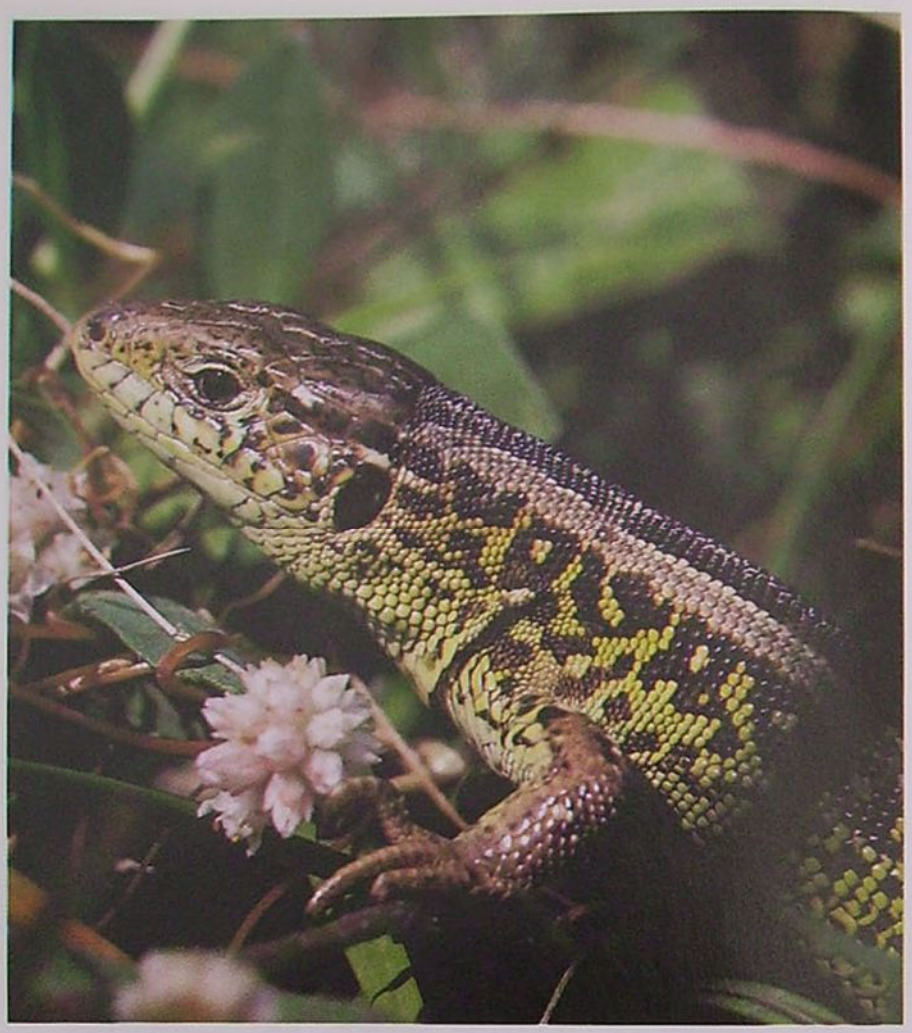
Why be subordinate? But where does the advantage lie for the beta male, to work so hard in the breeding season for so little reward? The answer may be that, being so low in the social hierarchy, he may be incapable of establishing and maintaining a territory single-handed. Without any territory he would be unable to breed, but by helping a more dominant bird he is able to live in a good territory and stands a chance, albeit limited, of making some contribution to the next generation.

The unexpected in bird life Most popular bird books readily show the more noticeable peculiarities that have evolved in birds' structures. Examples of these are the filter-feeding bill of the flamingo, the cone-opening mandibles of the crossbill and the bizarre head adornments of the ruff. Popular field guides fail, however, to illustrate the peculiarities of behaviour, and these may go unnoticed for many years. Only recently has the peculiar social behaviour of the dunnock been discovered–and this is one of our commonest birds! Perhaps some of our other common and apparently ordinary birds have exciting aspects of behaviour yet to be revealed to us.

Dunnock (*Prunella modularis*). Resident; Britain's only member of the accentor family. Length 14cm (5½in).

Above and right: Three phases of the mating behaviour of dunnocks. The middle phase, where the dominant or alpha male asserts his authority, is not an uncommon one, for trios are probably more frequent than pairs.

Below: Both parents feed the chicks, and if the beta has mated he helps too.



Above: A sand lizard basks in the sun. In this country these beautiful lizards are on the extreme edge of their European range, and their British population consists of a few isolated pockets.

Below: Four views recording the changes in the habitat. From left to right; September 1975, before the fire; September 1976, just after the fire; September 1977, with some regeneration of the heather; and September 1981–a suitable habitat for sand lizards once again.

CONSERVING THE SAND LIZARD

In 1976, fire reduced an isolated population of 800 sand lizards in Dorset to 30 homeless survivors. A conservation team laboured to save the colony.

Sand lizards are rare animals in Britain, now restricted to 'island' habitats–pieces of land which have suitable conditions but are far from the next area colonized by the species. Suitable habitats include certain nature reserves, some of which have been established with the rare reptiles in mind. But even well-managed nature reserves are not safe from the ravages of fire.

A tragic loss In August 1976 a particularly severe fire destroyed more than 70% of a National Nature Reserve on the Isle of Purbeck in Dorset. About 800 sand lizards had been living on the reserve, but sadly the fire destroyed most of their habitats; only a few, near one edge of the reserve, escaped the fire.

A group from Southampton University studying the ecology of the sand lizard, and headed by the author, visited the reserve as the fire was dying down. They found nothing but devastation. The charred remains of adders, smooth snakes and sand lizards lay among the ashes, as well as a number of dead specimens which had not been burnt, but had died from other effects of the heat–possibly suffocation.

To the surprise of the team, some adult sand lizards had managed to survive the fire. They cautiously emerged from burrows and holes in the ground, and scurried around in the blackened landscape. These surviving lizards were in danger of starving, because without plants there would be no small animals for them to catch. Also, the lizards were in danger of being spotted and eaten by kestrels or other birds.

The team therefore set about capturing these sand lizards, and during the next few days obtained 30 animals. Although some of them had burnt toes and broken tails, they seemed otherwise undamaged. Young and newly hatched lizards had all clearly perished.

The small vivarium The first concern was the immediate protection of the surviving lizards, and so the team released them in a small enclosure, or vivarium, which had been built earlier for the purpose of studying lizards. This lay a short distance from the nature reserve. With autumn approaching, the lizards would need to be fed, and the team set

about gathering spiders and insects. Feeding the animals would ensure that they gained weight before their period of winter inactivity.

The small vivarium was to be a temporary home while a suitable method was devised to return the lizards to the small unburnt portion of the reserve. The problem about this was that sand lizards, like some other animals, often try to return to their exact original habitat after they have been shifted. If they were simply released in the unburnt area, each might instinctively return to the spot in the burnt area where it had previously lived–even though this was now a totally unviable habitat.

The large vivarium The team set about designing and constructing a large vivarium in one of the unburnt parts of the nature reserve. Here the sand lizards would have room to settle down and breed, forming a small but captive colony. Having lived there for a few years, they would no longer have any memory either of their original habitat or of the small vivarium. The walls of the large vivarium could then be removed, and the lizards would gradually spread out and recolonize the National Nature Reserve as it became habitable once more.

For many weeks a small group of enthusiastic volunteers worked hard to build an ideal habitat for the sand lizards, albeit an enclosed one. They built a fence of corrugated plastic sheets, bolting these to strong stakes, and thus enclosed an area 18 × 30m (60 × 100ft). They protected the vivarium from birds and any other predators by spreading garden netting over the whole area, supporting it on poles.

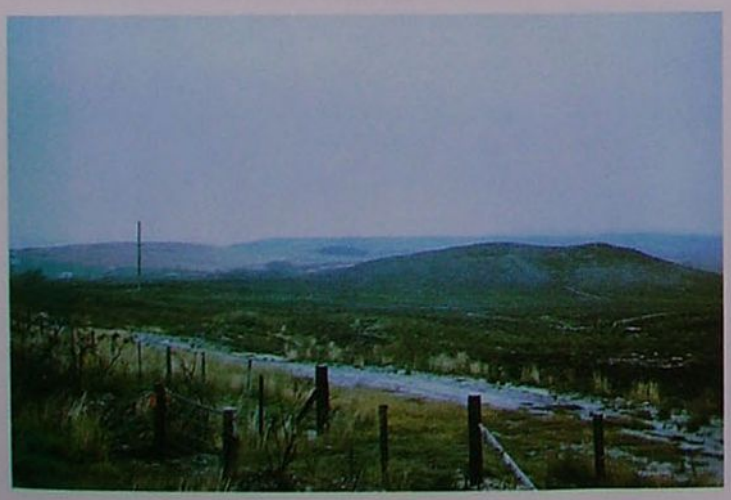
Above: A view of the large vivarium, with its walls of corrugated plastic sheets and its overhead net to keep out birds of prey. It was situated on an unburnt part of the nature reserve. The enclosure prevented lizards from heading for their former habitats, in which they could not survive.

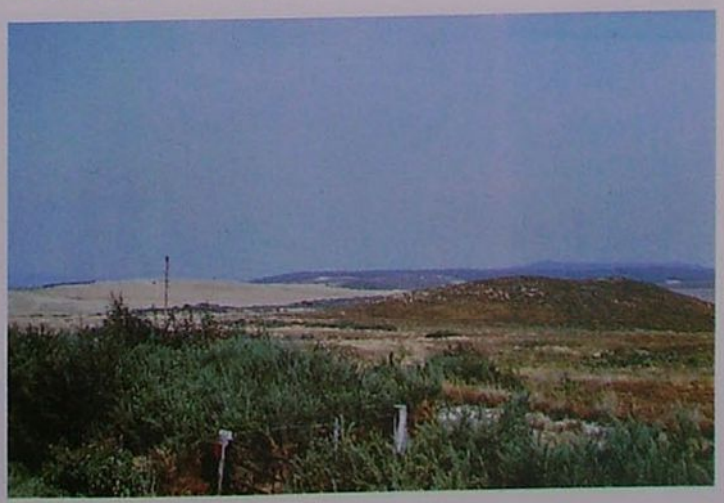
Below: When the area surrounding the vivarium was habitable for them once more, the lizards were released from captivity.

Vegetation inside the vivarium included some patches of old tall heather, a little bracken and some areas of short, young heather. To this the team added various new features for the lizards: large stones and logs, to provide good basking sites; and mounds of soft earth in which the animals could dig their wintering burrows. At regular intervals, the workers collected live insects and placed these inside the vivarium, where they settled.

A four-year stay By spring 1978 all was ready and the lizards were released in the large vivarium. During the rest of that year the team kept a close watch, and to the delight of all it was found that some female lizards had mated and laid eggs. In October, newly hatched lizards were seen. By this stage, too, the vegetation had grown and now provided shelter for the lizards.

When the team surveyed the whole reserve in October 1981, they found that the heather there had regrown to a suitable degree for lizards to begin recolonizing the area. The areas adjoining the vivarium now included good habitats for sand lizards, and in the spring of 1982 the vivarium was at last dismantled. Since then, the lizards have continued to increase in numbers and recolonize the habitat.





RIVER ISLANDS

The richness of riverine plants and animals is often greatly enhanced by the presence of islands, some of which may be small, temporary and unstable while others may be substantial.

For the wildlife of a river, one of the major values of islands is their isolation. This can be important for mammals and birds because it may decrease population losses by predation. However, both plants and animals are likely to benefit most if river islands are sufficiently small or isolated enough to make cultivation or development difficult.

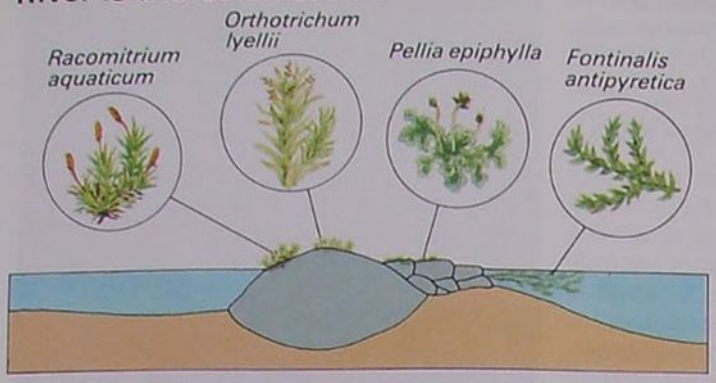
Types of islands There are two basic river island types–temporary and permanent ones. Temporary islands can form anywhere within a shallow river where floods cause erosion and there is subsequent deposition of eroded material. In lowland rivers which flow predominantly over rich alluvium or clay, islands are usually composed of soft silt or mud, whereas if the rivers flow over less rich soils the islands are composed of compacted sand, silt and gravel. In upland rivers with coarse substrates, and where high rainfall causes frequent erosive flooding, the transient islands are usually very unstable deposits of boulders, cobbles and pebbles.

Temporary islands are usually vegetated only sparsely, and often annuals predominate. When the next large flood comes, many islands are washed away and new bare islands develop elsewhere in the system. However, occasionally the initial sparse vegetation roots sufficiently tenaciously to rebuff the effects of the first flood, and as the water level recedes fine additional deposits are made to the

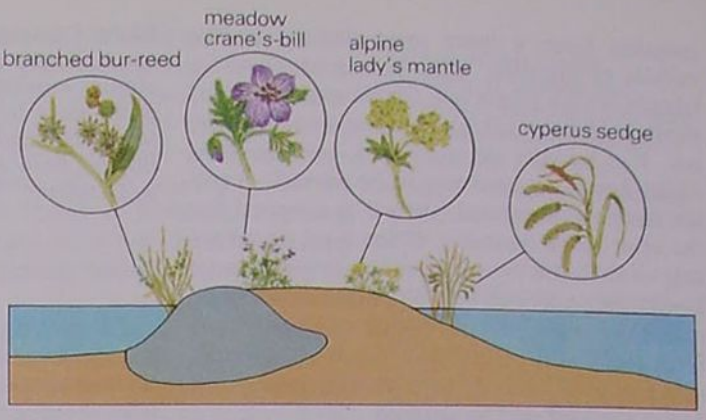
Above: A temporary island in the River Tweed, with canary grass growing on it.

Below: On rocky islands, where a particular boulder is frequented by birds, their droppings may so enrich the surface that algae and then mosses such as *Funaria* (shown here) may occur. The two birds you are most likely to encounter on and near rock islands are the dipper and the grey wagtail, both of which like to nest in crevices or on ledges.

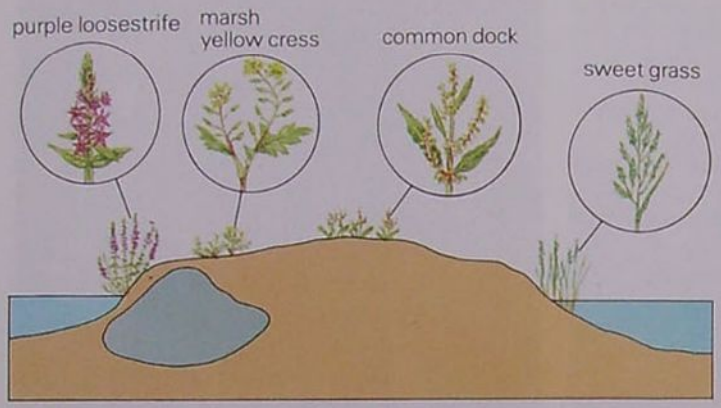
River island colonization



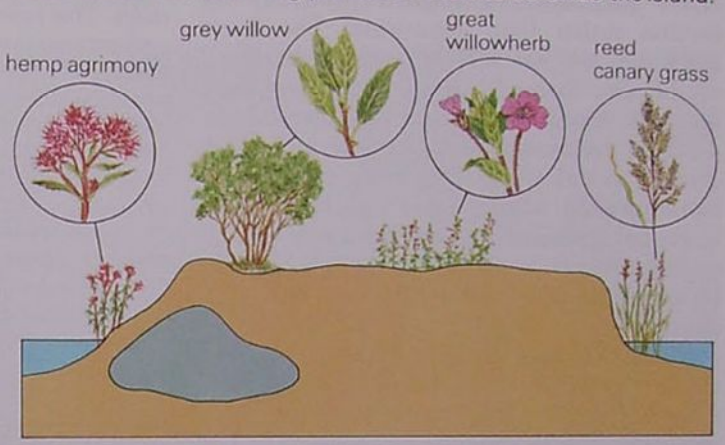
Primary colonization In initial island formation around a boulder, the submerged surfaces are colonized by mosses.



Silt accumulation Once the boulder has begun to accumulate silt, flowering plants can start to colonize the island.



Further growth A wider selection of flowering plants starts to colonize and the island spreads upwards and outwards.



The permanent island There is a succession from tall herbs through to scrub and eventually to mature trees.

islands. New species colonize, including perennials with deep or matted roots which start to stabilise the developing islands. As additional species grow, the island becomes more and more stable and eventually willow, sycamore, ash and alder saplings may take root.

All rivers have an exceptionally large flood every ten years or so, which tests a developing island to the full. Most are washed away completely, but if the saplings are rooted deeply, and the branches are sufficiently flexible to bend with the flood water, it is possible that a permanent island will be formed.

For islands or rivers to be regarded as permanent, they must show clear indication of having reached climax woodland vegetation or have been developed for industrial, domestic or agricultural purposes. Such islands are common in lowland rivers but in the uplands they are very rare. However, permanent islands are present in the uplands but these are composed of solid, erosion-resistant rock. These islands are also likely to be small. The smallest are extremely large rounded boulders which have been deposited by glacial movements thousands of years ago or during excessively large floods, whereas the largest rock islands are crags of resistant pavement which the river cannot erode.

Island formation There are many other ways in which an island can be formed, besides its

Right: A bird to look for on islands which are well vegetated, especially if there are alders–the siskin.

Below: The smooth, hard surfaces of rock islands are likely to be colonized only by simple plants. Examples include submerged filamentous algae such as *Ulothrix*, tough, leathery lichens such as *Dermatocarpon*, foliose and thalloid liverworts such as *Nardia* and *Pellia*, and mosses such as the *Racomitrium* shown here.

creation from a mere mud deposit in the middle of the river. The formation of rocky islands within rivers is a simple expression of the flow of water taking the easiest route to the sea. If a boulder or solid rock outcrop in a valley bottom is too large to be moved, or too resistant to be eroded, then it is simplest for the river to go round it. If the land on either side of the rock is at approximately the same height the water can be channelled on one side or the other and during floods it is likely that both sides will be utilised. Such floods will make inroads into any superficial deposits and a rocky island will be formed.

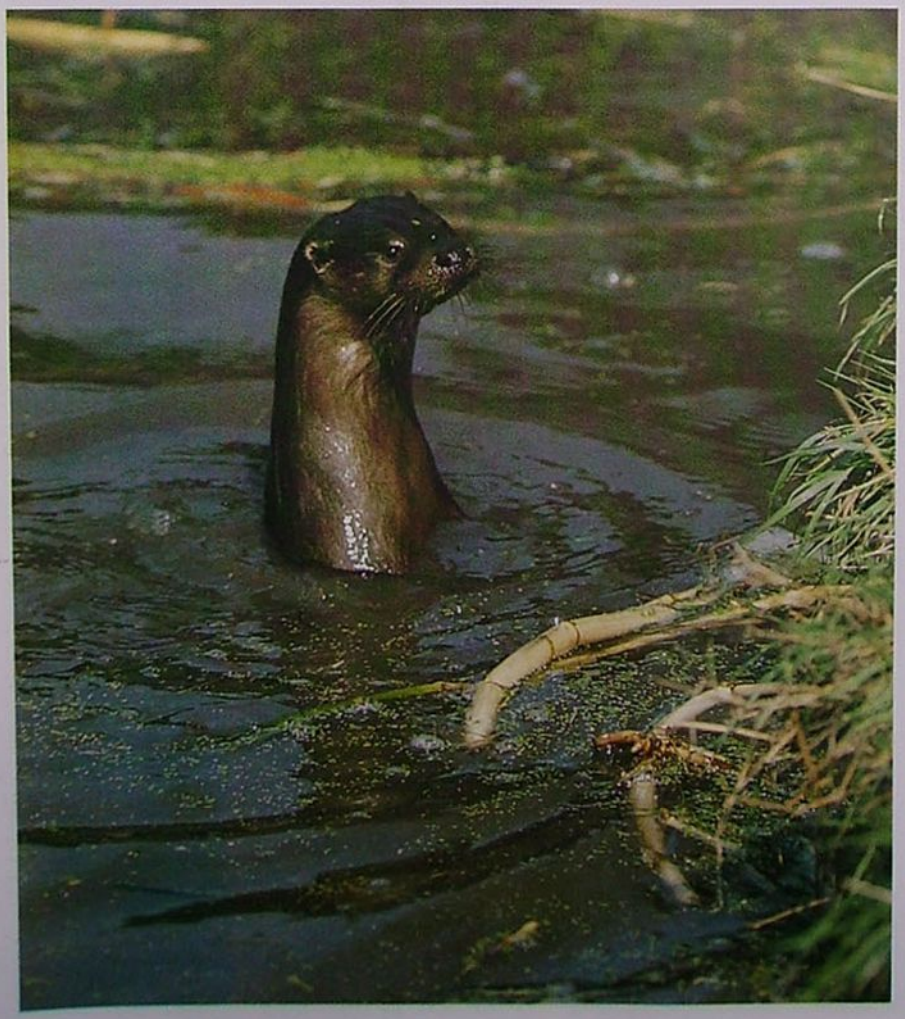
Natural earth islands in the flood plains of rivers may also be formed primarily by erosion rather than deposition. The finest examples are on incised meanders where islands are formed during floods. At such times the speed of the water flow may be too great for the meanders to cope with and a new channel is cut which by-passes its previous tortuous path. Such islands may be small or large, but few remain today since agricultural encroachments into the flood plain have necessitated the infilling of the old river course.

Plants of rock islands Extremely large rounded boulders deposited in the middle of a river can rarely support any flowering plant species at all. Although most common in the uplands, boulder islands do occur in the lowlands when a river traverses erosion-resistant rocks. Such islands occur in south-west England, Wales, the Lake District and Scotland. Wherever they appear, however, they all have a great deal in common. In general, their lower submerged surfaces are colonized by such mosses as *Fontinalis* and *Rhynchostegium*, while their exposed surfaces are often bare save for isolated lichens such as *Verrucaria*. Variations do occur, according to the geology of the rock, but the most exaggerated differences are seen where a particular boulder is frequented regularly by birds. Their excrement may so enrich the surface that algae such as *Prasiola* completely turn the surface green. As these in turn provide a thin layer of organic matter on the rock surface, new mosses such as *Funaria*, *Orthotrichum* or *Tortula* may occur.

On large rocky islands where cracks or hollows accumulate silt, however small the amount, the flora may be extremely rich. In narrow rock fissures showy plants grow in miniature, the restricted root growth reducing vegetative development yet stimulating flower production. The most spectacular species are more typical of neighbouring meadows, with globe flower and meadow crane's-bill providing bright splashes of yellow and violet, while alpine lady's mantle and alpine meadow rue have much subtler shades. The crevices also support grasses, sedges and rushes, alongside which may be found a miniature yellow member of the lily family–bog asphodel. In

Right: Common persicaria can be found on islands with mature vegetation. A member of the dock family, this plant produces heads of pink flowers from June to as late as October.

Below: An otter in water. Several species of mammals frequent islands, favouring those with large trees and a thick understorey of scrub or reeds. This type of understorey is the preferred haunt of otters, especially if the island is quiet and secluded. If the tall herbs, reeds and scrub are virtually impenetrable to man, the otters may well use the island as a base, from which they can patrol both the main river and its feeder streams. Among other mammals, Daubenton and pipistrelle bats often roost in the hollow trunks of dead or decaying trees. In winter, however, Daubenton bats return to caves and old buildings to hibernate.



rock hollows where most substantial deposits of silt may accumulate, the purple flowers of the common butterwort may be seen among the pink straggling flowers of pink purslane.

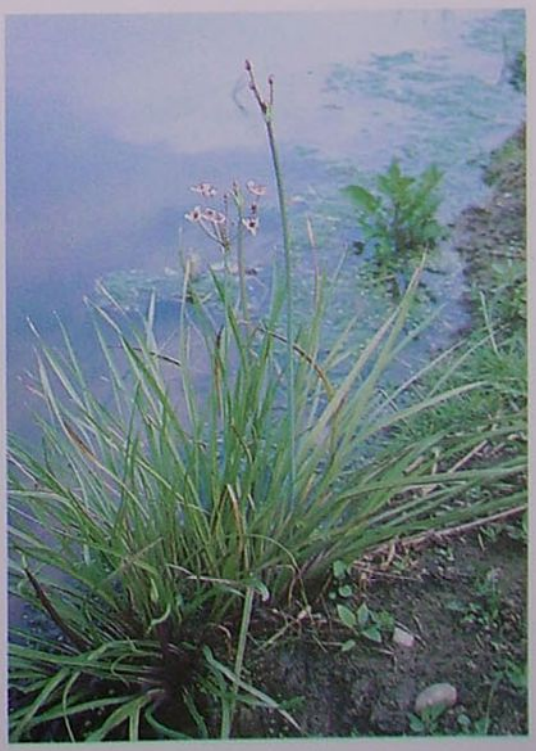
Temporary island vegetation The plants associated with the initial colonization of loose material thrown up to create islands by torrential floods is determined by the size of the particles and their ability to retain moisture. Upland islands generally comprise coarse gravels and large cobbles which drain rapidly. As these islands rarely last more than a few weeks, only fast-growing annuals with deep roots survive. In the middle reaches of rivers, where fewer cobbles are deposited and the gravels are finer, opportunist species such as shepherd's purse, common dock, ribwort plantain, redshank and lesser knotweed are quick to colonize. However, these are soon joined by, or replaced by, species more associated with rivers and wetlands in general. Species of sweet-grass, creeping bent, foxtail and canary grass help to stabilise the shingle, while balsam, creeping yellow cress, monkey flower and forget-me-not may produce a profusion of flowering colour. The succession to a mature island normally depends on the establishment of reed canary grass because it has an extensive matted root system which binds the shingle together. If it survives it will spread and trap more silt to enable the island to grow both upwards and outwards. If sufficient silt is deposited, willows will eventually colonize and a permanent island may form.

Islands which start initially from the deposition of fine silt in lowland rivers have a totally different plant assemblage. The early colonizers are again frequently annuals, with toad rush and nodding and trifid bur-marigolds being typical. These may be joined by brooklime and the pink and the blue water-speedwells. On particularly rich mud or in slow-moving rivers, watercress, amphibious bistort, great yellow cress and bittersweet are common. All these species have a combination of most of the prerequisites for success in such transient habitats–they can behave as annuals, grow fast, have a creeping growth or low profile and can root deeply to bind the mud.

Birds of vegetated islands In intensely cultivated river corridors a densely vegetated island within the river channel itself can be an ideal habitat for bird life which has been driven from adjacent land–finches, siskins and warblers all occur here.

Below: Although the building of bridges has destroyed many islands, they are now creating new ones. The islands are formed around mid-stream parapets which act either to collect debris and silt which form islands upstream, or as current deflectors which cause the deposition of fine particles downstream. Despite their isolation, river islands have been exploited by man in many ways–for wool and grain mills and road and rail networks.

Left: Nodding bur-marigold and (right) flowering-rush. For a young mud island to develop beyond the first stages of colonization, when such plants as the bur-marigold appear, it must show a succession to emergent reeds. The commonest is the bur-reed, but this rarely succeeds once the top of the mud is much above the surface of the water. The same is also true for the flowering-rush, but both species are important in the development of islands from mud because they collect debris and silt which raise the level of the deposits. As the mud becomes drier, reed canary grass and reed sweet grass dominate, and alongside these may be found purple loosestrife, hemp agrimony and great willowherb.



FARMING AND WILDLIFE

Today's agricultural practices exert immense pressures on the appearance and wildlife of the countryside. But there are encouraging signs as farmers and conservationists get together.

Left: An aerial view of the River Severn and a vegetated island. This type of mixed farming landscape–woodland, hedgerow, arable fields, rough ground and water–is not only good for all kinds of wildlife but it is pleasing to look at as well.

Below: Badgers–familiar inhabitants of many areas of farmland. Most farmers welcome them and in the few places where they are a problem they are selectively trapped.

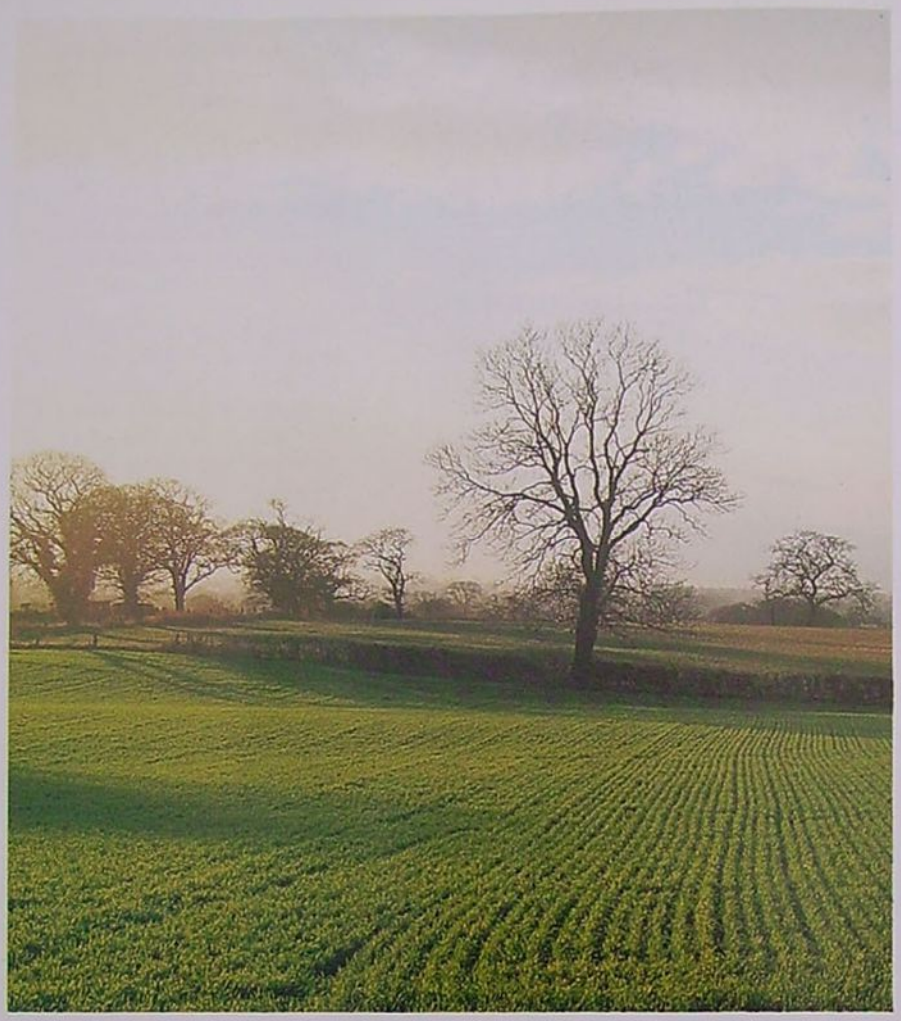
In recent years the conservation of the countryside has assumed special importance and has attracted much public comment and debate. Countryside management in the past has created the landscape, accepted by many people as being natural, which has maintained the conditions necessary for a thriving and varied wildlife. The shaping of the countryside has been influenced by three main factors: agriculture and forestry, field sports and the desire of landowners for amenity and privacy.

History of conflict There has always been a conflict between farming and conservation, with concern over changes brought about through new agricultural practices. During the enclosures of the 18th and 19th centuries many writers complained about the loss of open fields and the waste of land which resulted from planting hedges. Today's agricultural practices exert a greater pressure than ever before on both the appearance and the wildlife of the countryside. Arable farming requires no stock-proof boundaries and the fields are larger to accommodate huge machines. Every kind of farming activity exerts a direct influence on wildlife, especially the use of chemicals to control pests, diseases and weeds to produce food which reaches prescribed standards of size and quality.

It is, of course, easy enough to farm with little or no regard for the consequential effects on landscape and wildlife. It was the recognition of the apparent conflict between agricultural practice and countryside conservation that brought together a group of agricultural and conservation interests in 1969 at what has become known as the Silsoe Conference.

A combination of the specialist skills represented there showed that farming and wildlife conservation could be reconciled but, to be fully effective, conservation had to be planned with just as much care and attention to detail as was given to planning farming operations. The Farming and Wildlife Advisory Group (FWAG) was formed, with members drawn from the main organisations concerned with the countryside. County FWAGs were then set up, and today there are 53 local groups: one in every English and most of the Welsh counties and five in Scotland with more on the way.

FWAG advice There are of course many



sources of sound agricultural advice, and much information is available on conservation. FWAG's special contribution is to offer farmers advice on wildlife conservation that also takes account of the requirements of practical farming. It provides demonstrations, meetings and advisory leaflets as well as a forum where the many conservation interests–farming, field sports, nature conservation, landscape conservation, access, water gathering, forestry and others–can meet to discuss their problems and learn to appreciate each other's point of view.

The chairman is almost always a farmer, which encourages other farmers to see the group as helpful and not just another body telling them what to do. Advice may come from one or two members on a voluntary basis or through an adviser. This is welcome advice to farmers because it is independent of any one conservation group and, although it recognises the place of modern farm technology, it is not directly linked with agricultural productivity.

Farming and conservation Conservation is not just a matter of planting a few trees or clearing out the odd pond. A farmer must decide whether the existing habitat and features are worth retaining and maintaining. Established features are much more valuable than new ones: an old wood clear felled and reclaimed for agriculture cannot simply be replaced by new plantings. So the first action of a FWAG adviser is to assess what is there and devise practical measures for retaining and perhaps improving the existing habitats, at the same time ensuring that profitable farming continues.

Attention is also given to field boundaries and field size; there are no advantages from very large fields–16-20ha (40-50 acres) is adequate for most arable farms. Recent research has shown the value of field boundaries in providing over-wintering sites for insect predators which feed on cereal aphids. These predators, if encouraged, can often keep aphid numbers below the threshold at which chemical control methods are needed. Advice is also given on chemical control methods: fertilisers and chemical sprays should be kept out of hedge bottoms where they are only wasteful and damaging to the wildlife living there. Hedges should be trimmed when least harm will be caused to wildlife, and never during the bird breeding season.

Any major changes, such as drainage of wet areas or reclamation from woods or scrub to agricultural use should be considered most carefully. In some cases the land may in fact be more viable as woodland or old grass than as arable capable of producing crops only through heavy inputs of expensive fertiliser. There are a number of examples where draining a difficult two or three acres of a field would prove so costly that, on FWAG advice, the owner has instead created a lake or wet area which provides a wildlife habitat and possibly facilities for anglers. Field corners which are difficult to cultivate with modern machines, steep banks, track sides and other 'waste' places on farms can be planted with trees or shrubs. This not only improves the appearance of a farm but provides cover for

Above: Trees, hedges and winter corn are a happy combination to encourage wildlife. This view of the South Downs in Sussex (below) could be made more attractive by careful planning.

Some examples Several thousand farmers have received and acted on FWAG advice. A typical example in a Midlands county identified sites of highest wildlife quality which included two boundary streams and several pockets of woodland. The farmer was given advice on coppicing to ensure the survival of the ancient woodland, the removal of dead trees likely to block the watercourses and the planting of evergreen shrubs to provide winter food and cover for game. Wildlife corridors were identified and advice was given about hedge management, hedgerow trees, the removal of conifers and planting of taller trees. It was also suggested that the ponds could be cleared by cutting back the willows to

wildlife and, where there is an interest, game. Before these areas are planted, especially old grassland, it is a good idea to take advice because trees may in some cases be undesirable when interesting and important plants are growing. Native trees and shrubs should always be planted in preference to exotic species.

Above: Mixed deciduous woodland and hedgerows (right) need management. Hedges should be cut in winter to minimise danger to wildlife.

Below: Hawthorn and gorse hedges growing in Ireland.

allow more light to reach the water.

In another county a 32ha (80 acre) dairy farm has retained 5ha (13 acres) for wildlife and more than 200 trees have been planted around the farm. Weed control sprays are used only when it is essential and never on the river banks or track sides so that wild flowers are preserved. To produce the food necessary for a 70-cow herd, fertilisers have to be used on the grassland and pests must be controlled, but a compromise is sought wherever possible and the good results can be seen in the wide range of interesting plants, birds and mammals.

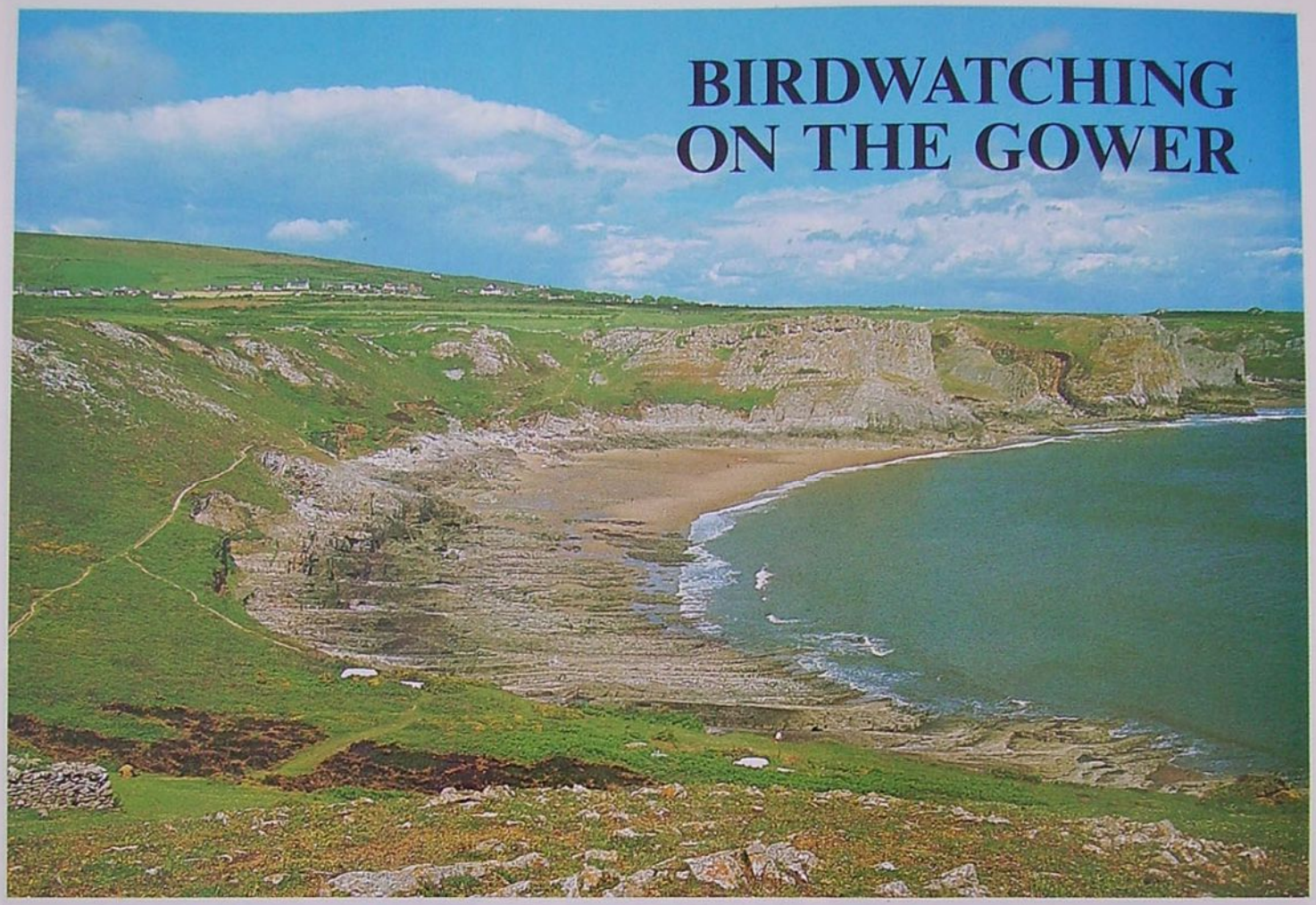
Another report on a farm in the West Country draws attention to the need to take the same care of the wildlife as of the farming interest. Major tree planting schemes are now in hand with the emphasis on broadleaved species. Older trees are being positively managed: trees do not live for ever and careful felling and replanting maintains a site indefinitely. Ponds are being created and old buildings cared for as a refuge for owls and bats. The aim is to create a situation where the various elements of the farm, livestock, land, wildlife and their different habitats mesh together in a natural whole.

The future There is a demand for greater control over some farming operations, particularly such matters as hedge removal, the ploughing of old grassland and conversion of woodland or scrub to arable or intensive grass. At present farmers are simply under a moral obligation to take care of the countryside and to exercise voluntary restraint when dealing with such features. Whether the future lies in control or voluntary action, advice and information will still be needed; FWAG can make a valuable contribution to conservation as well as productivity.

Above: Old farm buildings make ideal nesting places for birds such as barn owls.

Below: The northern end of the Lake District's richest lake, Esthwaite Water, fringed by sedge swamp, alder carr and common reeds.

BIRDWATCHING ON THE GOWER



Above: Fall Bay, the widest bay on the walk. In the background two villages run together–Rhosili on the left and Middleton on the right, where our trip began. The rock shelf of Crabbut is seen at the near end of the beach. At the far end is the cliff where rock climbers threaten the formation of a fulmar colony. Thurba is off the picture to the right.

Below: The rock pipit nests in Fall Bay, often feeding on picnic leftovers.

We joined Jim Flegg, master birdwatcher, on a field trip along the cliffs to Worm's Head, to observe the bird life of the rocky Welsh coast.

The track down to the cliffs lay between overgrown hedgerows. Almost as soon as we had set out, Jim interrupted the conversation in mid-stride to point towards the thicket: he had seen a female whitethroat feeding her young, where to the inexperienced eye only the dense foliage of July was visible.

'You can't expect to make such precise observations until you've been out quite a few times,' Jim said. 'The best advice is simply to visit the same area or the same type of habitat as often as you can, and to look–and listen–for yourself.'

A warm, sunny spell was setting in at midday as we arrived at the top of a rocky headland called Thurba. Some gulls were wheeling overhead, and we sat down to observe them. Jim showed no sign of trying to hide: he moved carefully and deliberately, never suddenly, but as long as we kept at a minimum distance of about 3m (10ft) the gulls were not unduly disturbed.

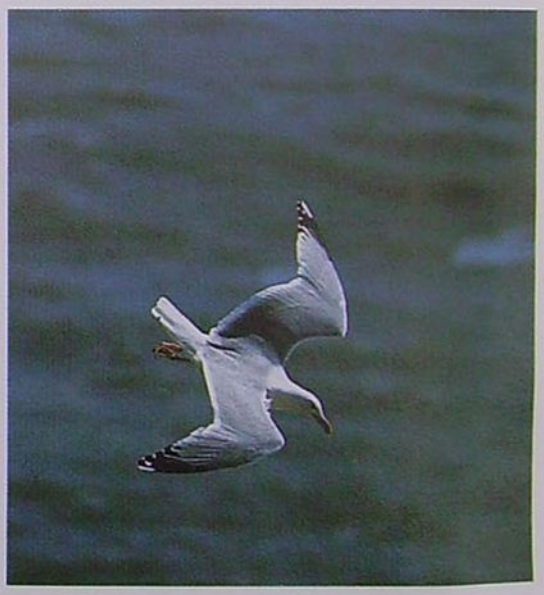
Cliff colony These were herring gulls: their wings were silver grey on top, with bold black markings just inside the white wingtips. This cliff was the site of their colony, and quite a number of pairs were watching over their large grey chicks.

Thurba consists of a 'knife' of rock, rising some 50m (160ft) above the sea. Besides the herring gulls, a great number of other birds filled the air and sea around it. We soon saw a gannet: this large white seabird, with slender, black-tipped wings that had twice the wing-span of the gulls, was flying along the coast, some hundred metres offshore and a few metres above the water. As we watched, it interrupted its flickering flight and plunged down into the sea with wings trailing, making a considerable splash. After a second it emerged once more and continued its solitary

Above: The kittiwake colony that we watched on the trip. Here again, rock climbers threaten to disturb bird life. They have left some of their tackle in the foreground.

Left: These fish bones are the remains of a gull pellet: what the gull cannot digest it coughs up in a pellet, rather like that of an owl. Some gull pellets on Thurba were evidence of scavenging from rubbish tips, for they contained remains of paper and textile fibres.

Right: A herring gull wheels round Thurba.



journey. Watching through the binoculars, we could just see the wriggling form of the fish before it was swallowed.

Jim showed me three fulmars that were sitting below us on a ledge–pearly grey and white birds that looked remarkably meek and contemplative, when you consider that they are quite ready to spit a vile-smelling fluid on any intruder that disturbs them. The full list of birds nesting on this cliff also includes swifts, feral pigeons, jackdaws and little owls.

We were ready to leave Thurba when Jim saw another interesting sight–a heron way out over the sea. At first it seemed to be steering a course for Thurba, but a number of gulls saw it off. The heron flew further out to sea, and then continued northwards. With its broad wings beating methodically, it was soon far away. 'It's got the endurance to fly to Pembrokeshire if it wants to,' was Jim's comment (Pembrokeshire is some 40km/25 miles away).

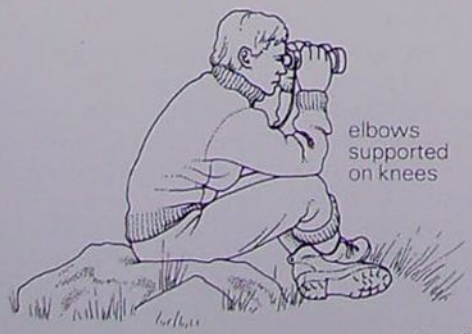
Quiet kittiwakes Our next stop was beside a kittiwake colony at the beginning of the next headland. These delicate little gulls were sitting with their chicks on tiny ledges, some only inches wide. Once again, Jim did not make a great show of hiding from these seabirds: he simply sat down on the grass in full view of the birds, and continued talking in a normal voice.

'There's very little movement at this time of day and year,' he said, 'they're still waiting for their lunch–the parents take turns to fly out and fish, and the main time for feeding is early in the morning anyway.'

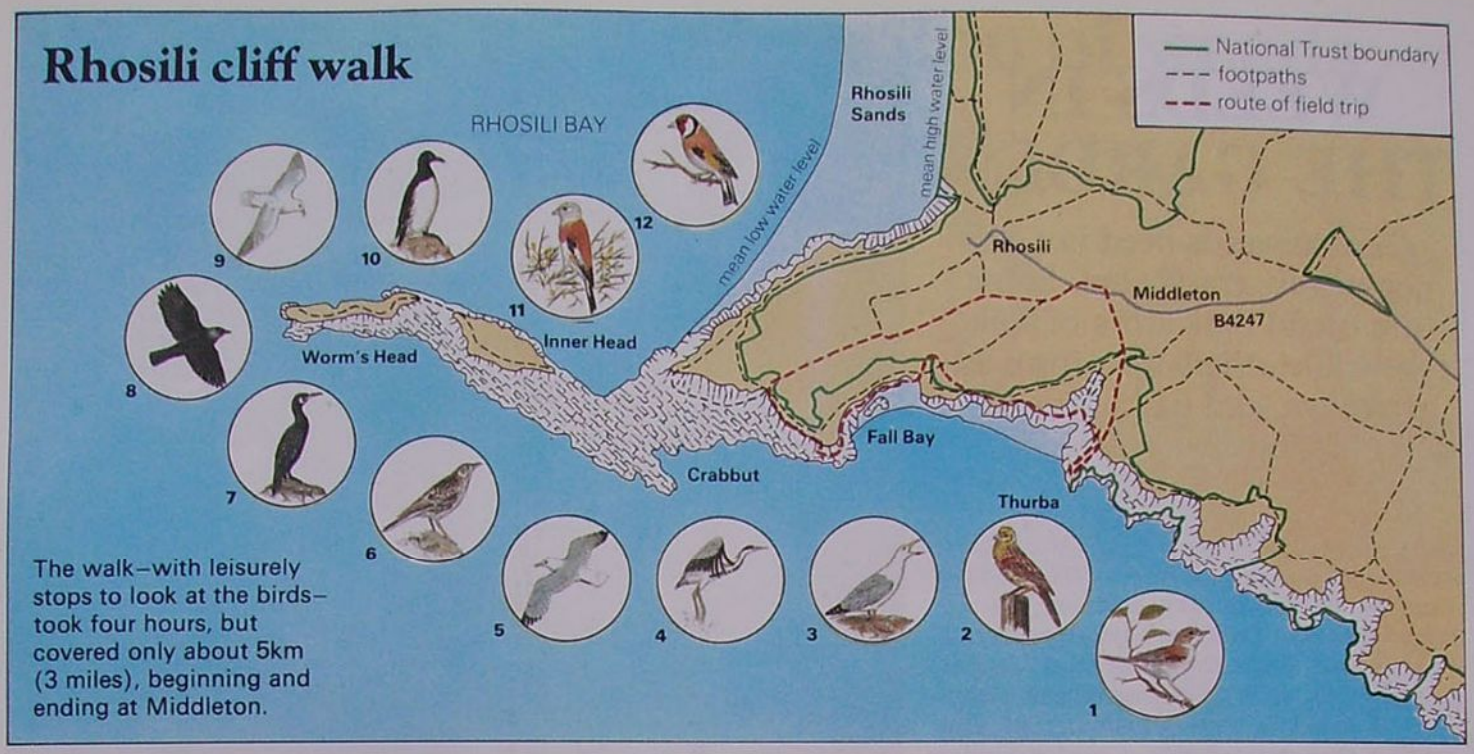
Through the binoculars, we watched the kittiwakes waiting with their white chicks in the sunshine. Many a beak was open, revealing a bright red inside, for the adult birds genuinely pant in hot weather to cool themselves.

The next cliff we stopped to look at was 80m (250ft) high, with plenty of ledges and crevices, and a prize ascent for learner rock climbers. This is a pity, for unless the climbers

Points about binoculars



1 Be careful not to go dangerously near to a precipice just to get that better view.
2 Support the binoculars as firmly as you can. In mild weather you can simply sit resting elbows on knees.
3 In blustery weather, lie flat and rest elbows on the ground.



Above: The inset pictures on the map show a selection of 12 of the many bird species that have been recorded on this stretch of the coast.
1 whitethroat,
2 yellowhammer, **3** herring gull, **4** heron, **5** kittiwake, **6** rock pipit, **7** cormorant, **8** jackdaw, **9** fulmar, **10** guillemot, **11** linnet, **12** goldfinch.

Below: Shags are related to cormorants but are more slender in build. During our visit we watched a swimming shag dive for a fish. It surfaced after 30 seconds, then took off in a laboriously slow climb.

can be persuaded to go elsewhere during the breeding season they will prevent an interesting phenomenon: the possible establishment of a fulmar colony.

Home of the rock pipit We crossed Fall Bay with its low shelf of rock that proved to be a rich fossil bed. The shelf continued round the next headland, and soon we saw a different landscape. The most dramatic feature was Worm's Head (or simply the Worm), a green block of turf-covered rock that protrudes some 100m (320ft) from the sea, joined to the land by an extension of the rock shelf. This natural causeway, which is covered by the sea at high tide, began where we stood, in an area known as Crabbut.

The limestone layering of Crabbut is partly vertical and partly flat; while the flat lying rock is smooth, the vertical pieces are a maze of sharp, twisted crags up to the height of a man. They would be difficult walking for us, but they are a prime feeding place for the rock pipit, and soon we could see one of these streaky, brown birds.

Across the water We reached a good vantage point and sat down to look at the Worm. 'It's as well not to go out there,' Jim said, 'plenty of people do, but puffins and guillemots don't like being disturbed, and I for one am inclined to leave them alone in the hope they'll stay. Apart from Lundy'–he nodded towards a hazy blue shape out to sea–'this is about the furthest east that puffins are found these days, and they're on the retreat.'

We scanned the cliffs, some 300m (340 yards) across the water. Two splashes of white –the guano, or accumulated droppings–gave away the location of two small colonies; we spent a while watching the cormorants and guillemots that were breeding there, and then returned to our starting place at Middleton.

How to become a birdwatcher

The first thing anyone should do when planning a birdwatching trip is to consult a reference book to know where to go and what to look for. In each county, the Naturalists' Trust is likely to be the best contact, and many Trusts publish lists of good birdwatching locations. You can also arrange to go on guided trips with experienced birdwatchers, either with the local RSPB group or with local natural history or ornithology clubs. Once you have made, say, half a dozen thorough visits to the same place or the same type of habitat, you would most likely know enough to name the majority of the birds you see there. After this, you can expand your knowledge to the species that remain unfamiliar to you. It helps to know one site really well.

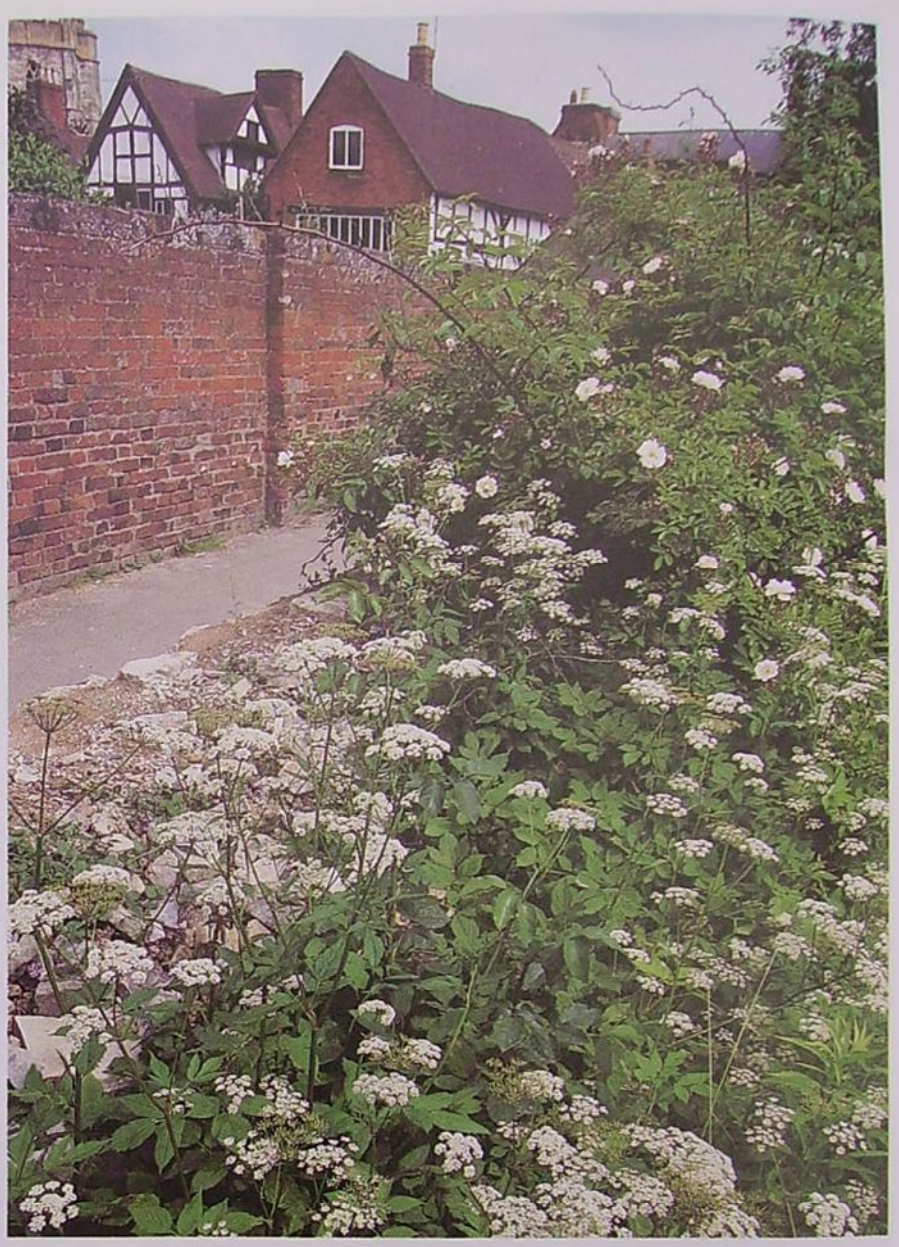
WEEDS IN THE GARDEN

Garden weeds need not be completely eradicated. Some are useful indicators of soil type while others may form an attractive wild patch or even rectify mineral deficiency.

The word weed is a corruption of the Anglo-Saxon word 'woed' meaning a herb or small plant, so its present-day meaning can be defined simply as a wild herb growing where it is not wanted. Not only are the most familiar garden weeds, such as groundsel and bittercress, included in this definition, but also anything that springs up in a garden border and is considered undesirable–even orchids may fall into this category.

Most tidy gardeners consider garden weeds as uninvited guests and, if left to complete their life-cycles, many have the potential to smother the plants that have been grown for their beauty or food value. It should be remembered, however, that an aggressive weed in one environment may be a charming wild flower in another. Some weeds can be a valuable addition to the garden, with such virtues as attracting wildlife and adding to both the chemical and physical properties of the soil.

Crossing the garden fence For weeds to be successful they must have effective methods of dispersal; as any gardener realises, many of them have. The seeds of brambles are transported in bird droppings, while thistle seeds are carried into the garden on wind currents. More cunning methods are adopted by such weeds as goosegrass, the hooked fruits of which readily cling to fur and clothing. (Ironically, the spread of the plant is encouraged by the very people who spend hours



Above: Ground elder (*Aegopodium podagraria*), one of our most persistent garden weeds, is capable of spreading through shrub borders unabated by the savagery of a garden hoe or even some of the stronger weed-killers.

Above right: Some weeds are useful indicators of the soil conditions in your garden: the presence of the notorious horsetail (*Equisetum* sp.) is a clear sign of bad drainage.

Right: Lady's smock (*Cardamine pratensis*) or cuckoo flower as it is otherwise named, is another weed of poorly drained soil.

Left: Scarlet pimpernel (*Anagaltis arvensis*) is an indicator of alkaline soils.

eradicating it from their gardens.)

Some weeds are notoriously persistent. For example, the seeds of shepherd's purse can remain in the soil for up to 16 years, only germinating when conditions are just right. Other weeds, such as hairy bittercress, are capable of producing several generations in a single growing season.

Lawn weeds The weeds occurring on lawns have special adaptations to avoid serious mutilation from the lawn mower. Rosette-forming species such as ribwort and cat's ear, for instance, keep their growing tips close to the ground. Irritatingly for the gardener, such weeds depend on the surrounding grass being cut regularly, because this minimises competition for light; if the grass is allowed to grow longer then these weeds would event-

Stages of colonization

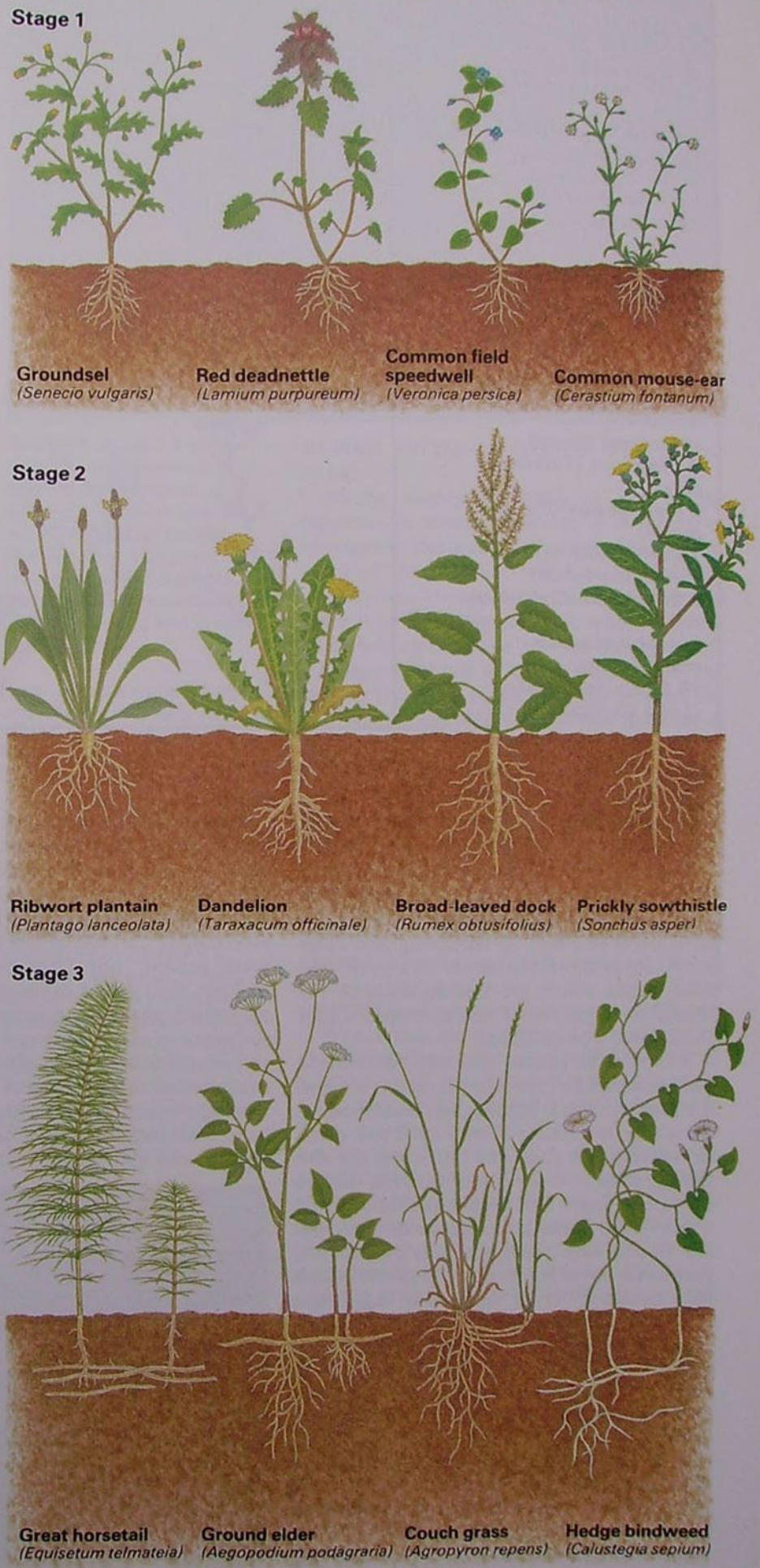
Gardeners know only too well how rapidly bare soil is invaded by weeds. Weed colonization follows a pattern, although it depends on the soil type and nearby vegetation. Here we examine what happens if a previously well-worked plot with soil which is not too acidic or alkaline is left fallow for three years.

Stage 1 In the first year, during the latter part of March, the soil warms up and initiates seed germination. Annuals are the first to appear.

Stage 2 Towards the end of the first year many of the perennial weeds are prominent. Unlike annuals they have long, tough taproots penetrating deep into the soil. Carpet-forming weeds also appear and gradually encroach on to the bare soil.

Stage 3 During the second season a pattern emerges with the stronger perennials choking the weaker annuals. Other weeds encroach on to the plot from surrounding areas. If left uncultivated for a third year there would be a dominance of woody and herbaceous perennials.

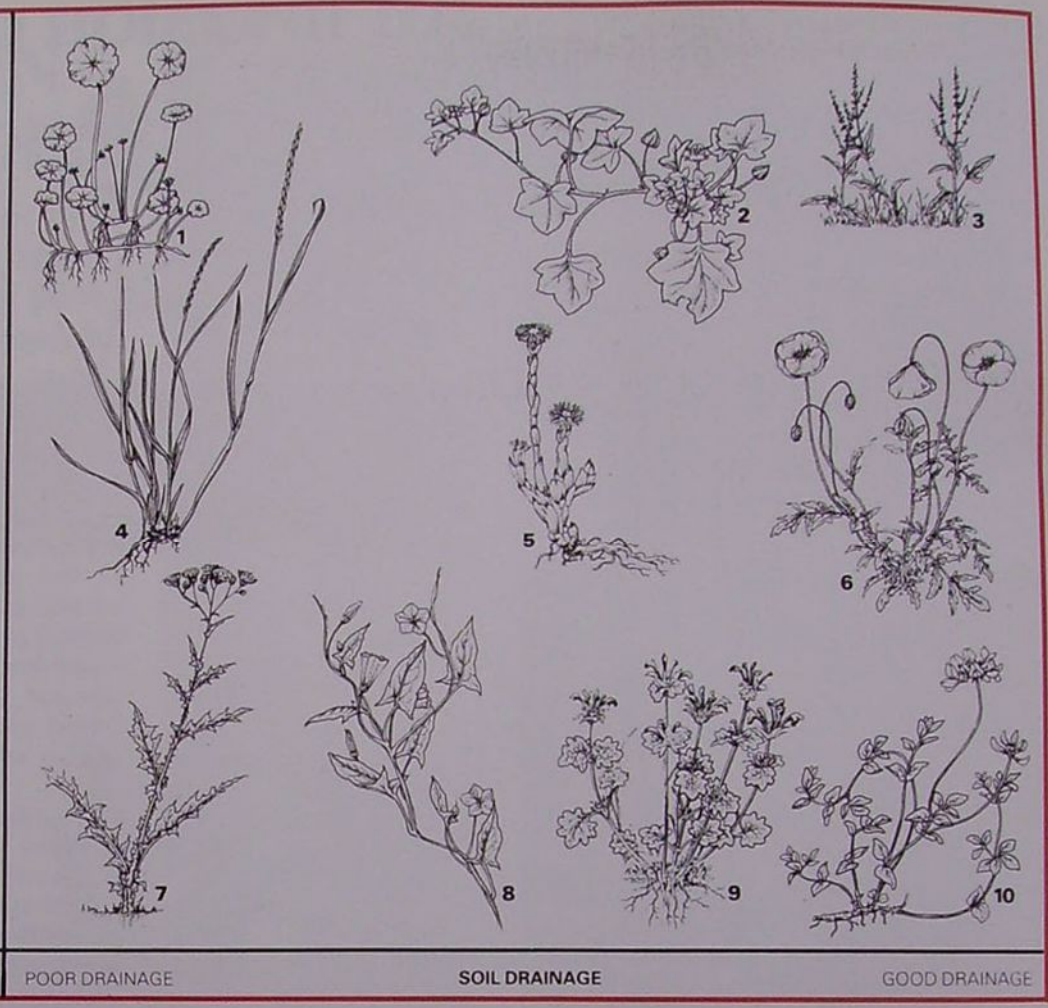
An invasion of weeds



Weeds as indicators

Garden weeds can be useful indicators of soil type. Use this chart to find out the soil conditions in your garden. If marsh pennywort is thriving in the flowerbeds this indicates that you have poor drainage and the soil is too acidic.

1 Marsh pennywort (*Hydrocotyle vulgaris*).
2 Ivy-leaved speedwell (*Veronica hederifolia*).
3 Sheep's sorrel (*Rumex acetosella*).
4 Couch grass (*Agropyron repens*).
5 Coltsfoot (*Tussilago farfara*).
6 Field poppy (*Papaver rhoeas*).
7 Corn sowthistle (*Sonchus arvensis*).
8 Bindweed (*Convolvulus arvensis*).
9 Henbit (*Lamium amplexicaule*).
10 Bird's-foot trefoil (*Lotus corniculatus*).



ually die out. Other weeds which flourish unabated in lawns are those like clover and pearlwort that form tight creeping mats.

Down the garden path Pearlwort is also an effective colonizer of gravel paths, along with stag's-horn plantain. Both these weeds are particularly resistant to trampling and commonly occur down the centre of a path. The taller weeds which are less resistant to the human foot–groundsel and mayweed–occur on the path's outer limits.

It is hard to believe that any plant could penetrate surfaces like tarmac, but as soon as the slightest crack occurs then dandelion, in particular, is pushing its way up. Thale cress, annual meadow grass and bittercress are also typical weeds of the joints between paving slabs, and thrive well despite the lack of soil.

Flowerbed weeds Although weeds in general are viewed with contempt, it is perhaps the pernicious invaders of flowerbeds for which the gardener saves his most aggressive language. Perennials such as ground elder, rosebay willowherb, creeping thistle and couch grass are among the most persistent intruders, even capable of spreading through shrub borders. It is only hard work with a garden fork that prevents such weeds from over-staying their welcome. Worst of all are bindweed and the horsetails, whose roots penetrate many feet into the soil. Bindweed is particularly effective in smothering other plants and, therefore, of denying them vital sunlight.

Plants as indicators So far it would appear that weeds are a nuisance to the gardener. But there are a number of species which have their uses. Noting the different species of weeds and where they grow, can be of immense help in ascertaining the type of soil there might be in your garden: not only can some weeds indicate the type of drainage in the soil but also which particular minerals are lacking. A sudden crop of daisies may well mean that the soil is deficient in lime. Daisies are rich in calcium and as they die and decompose they naturally enrich the soil with the calcium they have absorbed, thus correcting the deficiency. Docks and dandelions are also good in-

Below: Hairy bittercress (*Cardamine hirsuta*) thrives in sites where there is little soil, for instance, stone walls and the joints between paving slabs. This weed has a very effective means of dispersal and can spread at an alarming rate. One plant is capable of producing several generations in one growing season and, under suitable growing conditions, the seed germinates and reaches maturity within 15-20 days, each plant producing more than 100 seeds.

dicators of mineral deficiency; their long taproots are capable of extracting minerals from deep down in the subsoil.

The presence of the notorious horsetail in a garden is a clear sign of bad drainage, and once the fault has been remedied, this plant disappears as quickly as it appeared. Although such weeds as coltsfoot and sow-thistle also indicate a heavy, badly drained soil, it could be argued that they are beneficial, because their penetrating rootstocks are excellent at breaking up the subsoil. If groundsel, one of our more common garden weeds, flowers when only about 5cm (2in) high, then it is an indication of a soil lacking in fertility. In a fertile soil a well-grown groundsel plant will reach a height of 60cm (2ft) or more.

Above: A perennial weed found in gardens is corn sowthistle (*Sonchus arvensis*). Another species which thrives on poorly drained soils, this plant may be regarded as beneficial, for its rootstock penetrates deep into the ground and breaks up the subsoil.

Left: Sheep's sorrel (*Rumex acetosella*) is closely related to the docks, a group of plants renowned among gardeners for their long, tough taproots which venture deep into the soil, making them particularly difficult to eradicate.

Below: At its best, germander speedwell (*Veronica chamaedrys*) can form a carpet of sky blue. So why not leave aside a wild patch in the garden where some of the more attractive weeds can grow wild? Both this species and round-leaved speedwell (*Veronica filiformis*) grow in short grass.

Strong vigorous growth of any of the leguminous weeds indicates a shortage of nitrogen in the soil. The bacteria living in the roots of these plants, which include clovers and vetches, absorb nitrogen from the air and store it in the nodules, from where it eventually passes into the rest of the plant. By cutting off the top of one of these plants and leaving the roots to decay in the ground, the soil greatly benefits from a free dressing of nitrogen.

Patch of wild flowers It can be said that certain weeds, especially the more colourful species, have a place in the garden. This does not mean to say that cultivated borders and vegetable plots have to be an unruly mass of ubiquitous weeds. Instead, a small patch can be set aside and carefully managed. This can be particularly effective if an area of lawn is allowed to grow rough, just mowing it once or twice a year, preferably in the late summer when the least amount of damage could occur.

Weeds can be naturalised in an area of established lawn, or better still, the seed of selected weeds may be sown in with the grass seed on a freshly prepared piece of ground. You can use different types of grass, incorporating both the taller grasses and the smaller, finer species. This would then broaden the variety of weeds that could be utilised. (Some weeds prefer to grow in short grass, others in tall grass.) Once the area has become established, and harmony between the weeds and the grasses has been achieved, then the definition of weed would no longer apply.

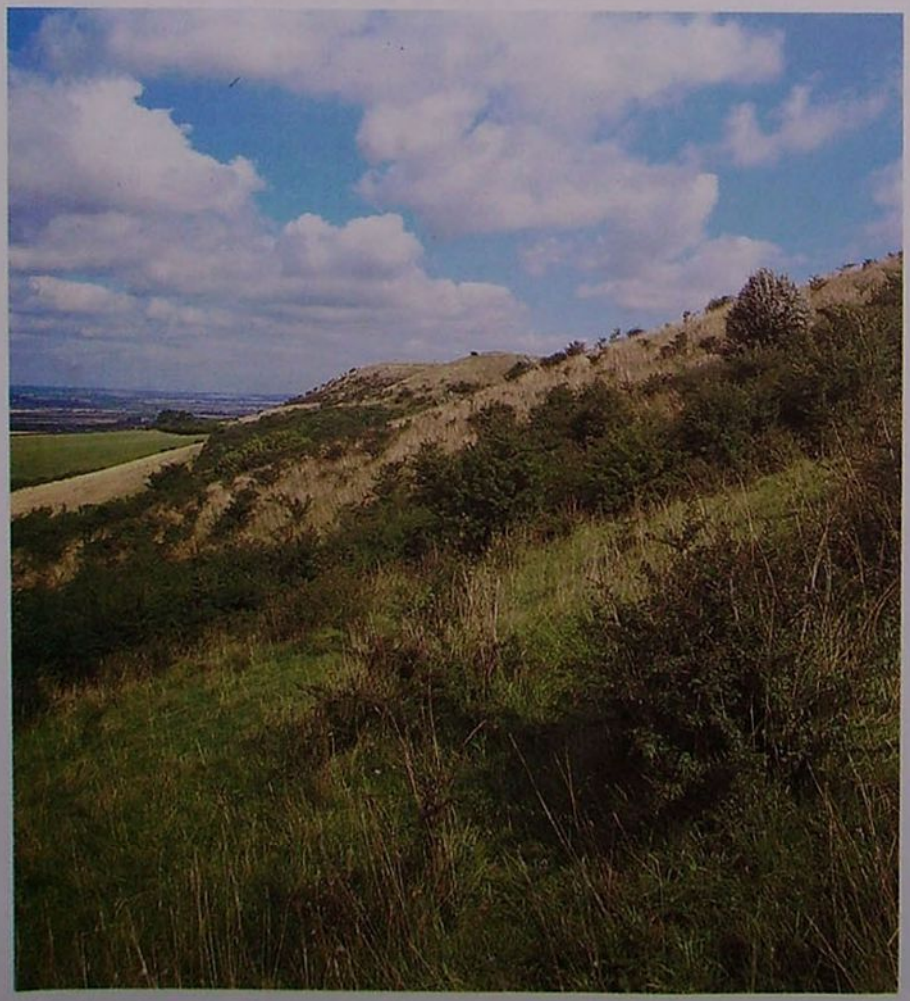
Nettles as a plant food Of all the weeds in the garden that are of some benefit to man, it is perhaps stinging nettles that head the list. The average gardener must spend hours trying to rid his garden of this weed; if only he knew of the many uses he could put it to. For instance, if nettles are soaked in rain water for two to three weeks, the resulting liquid can be used as a very effective plant food, especially for tomatoes.

CONSERVING OUR INSECTS

Insects may seem common enough in summer, yet many of our 20,000 British species are on the decline and in need of conservation measures, whether for their usefulness to man as parasites of pests or for their interesting life histories or habits.

Below: Many insects face the problem of habitat loss. This chalk downland scene is dominated by encroaching scrub–the result of the lack of grazing by rabbits and domestic animals. Butterflies, such as the silver-spotted skipper (below right) and the adonis blue, prefer the short turf of grazed downland. The stripe-winged grasshopper, now an uncommon species, has also been affected by the loss of chalk downland.

One of the chief problems facing insect conservationists is the lack of public interest and sympathy for their cause. Many people show concern for showy species like the swallowtail butterfly, but have difficulty in becoming enthusiastic over an endangered grasshopper or beetle. Most people regard the loss of a species of fly or bug as beneficial; indeed it is traditional to think of most insects as pests of home and garden. This has meant that until recently only the colourful insects such as butterflies have attracted public concern. However, the success of Butterfly Year 1981-82 has already set in motion conservation projects that will also be of benefit to other insect groups.



Conservation bodies Many organisations exist to promote public awareness of the need to conserve British insects. The main share of responsibility is taken by the Joint Committee for the Conservation of British Insects (JCCBI), formed in 1968 by the Royal Entomological Society of London to advance this cause. This body is made up of representatives and observers from the main entomological societies of Britain and Government bodies such as the Nature Conservancy Council and the Forestry Commission. The list of achievements of the JCCBI include: planning and organizing Butterfly Year 1981-82; drawing up a Code for Insect Collecting; promoting ecological studies of threatened species; and providing advice and help on conservation problems. Some of the insect species that have been helped include the rainbow leaf-beetle, the Essex emerald moth and the heath fritillary and silver-spotted skipper butterflies.

Climatic change One of the few factors affecting insects that are outside man's control is changes in climate. These tend to affect species which are on the edge of their European range in Britain. Species which fall into this category include the heath and Glanville fritillaries, and the field cricket. They are vulnerable because they survive here only by evolving to suit local conditions.

Habitat destruction The most worrying threat to many insect populations is the loss of suitable habitat. Huge areas of heathland and chalk grassland have been ploughed up since the 1940s. The remaining pockets are now the refuge of a multitude of threatened insects, including the adonis blue butterfly.

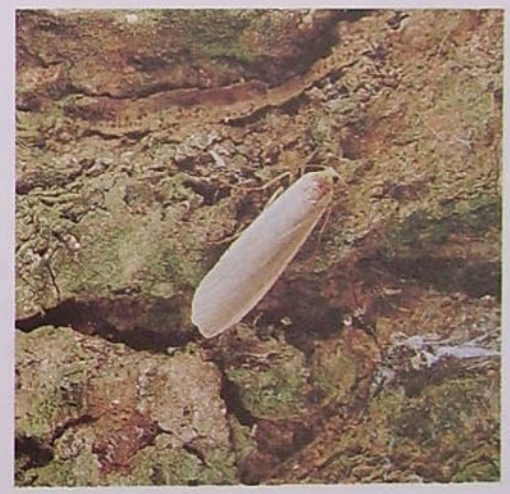
Practical answers We still know very little about the ecology of many British insects that are threatened by extinction. Until such knowledge is acquired, we cannot hope to manage and conserve as successfully as we would wish. The involvement of professional entomologists at an earlier stage might have saved the large blue from extinction. The conservationist needs to be one step ahead of extinction by recognising the difference between a natural fall in numbers and a steady downward trend.

Man-made threats

Above: The pollution of our waterways, lakes and ponds has badly affected many aquatic insects such as the Norfolk aeshna (above right). Fertiliser run-off from agricultural land causes rapid growth of plants in rivers, in turn leading to blocked waterways and a reduction in the oxygen level of the water. The initial proliferation of plant life may appear to encourage wildlife, but the changes in habitat will inevitably lead to the loss of many interesting insects.

Below: Atmospheric pollution from industry and homes kills lichens and other foodplants of certain insects like the common footman moth (below right). Gases, such as sulphur dioxide, dissolve in rain water to form dilute acids which are particularly deadly to lichens on trees. The loss of these plants in urban areas has caused the decline of many insects.

Bottom: The extinction of the large blue butterfly in 1979 has been attributed to changes in land use. The natural habitat of the large blue has short turf that encourages the ant *Myrmica sabuleti*, upon which the large blue depends. This ant takes the tiny caterpillar down into its nest where the caterpillar feeds on ant grubs. The loss of rabbits, due to myxomatosis, and the removal of sheep led to under-grazing of the sites. The increased depth of grass and other vegetation made the habitat too cool for the *Myrmica* ant which was replaced by species unsuitable as possible hosts for the large blue caterpillars. Similar changes in grazing regimes are also affecting other butterflies such as the chalkhill and adonis blues.



BEEF–FROM CHEAP STOCK, FEED AND LAND

Cattle are very inefficient meat producers. They put on weight slowly, consuming vast quantities of food in the process. Given the opportunity, they will eat right through the farmer's profit margin to be sold plump and glossy at a substantial loss. Farmers are therefore very cost-conscious.

Above: Beef cattle in the snow. Some of the best beef comes from upland areas which support breeds such as the long-horned Highland and the Galloway (below). They have shaggy coats and can withstand extreme weather without loss of condition. In lowland areas it is common to find Hereford (beef)/Friesian (dairy) crosses such as these bullocks (below right). The calves are quick-growing.

The traditional beef rearing areas of the British Isles are the pastoral uplands of the north and west–regions with a cool, wet climate and poor soil unsuited to arable farming on a large scale. The pasture is often too poor to support modern high-yielding dairy cattle, but quite adequate for the less demanding beef breeds, stocked at low density on cheap land. The animals are bred to be self-reliant and hardy enough for outwintering in a sheltered field on a simple diet of hay, silage (preserved grass) or barley straw. This saves the cost of winter housing which is almost universal today on dairy farms.

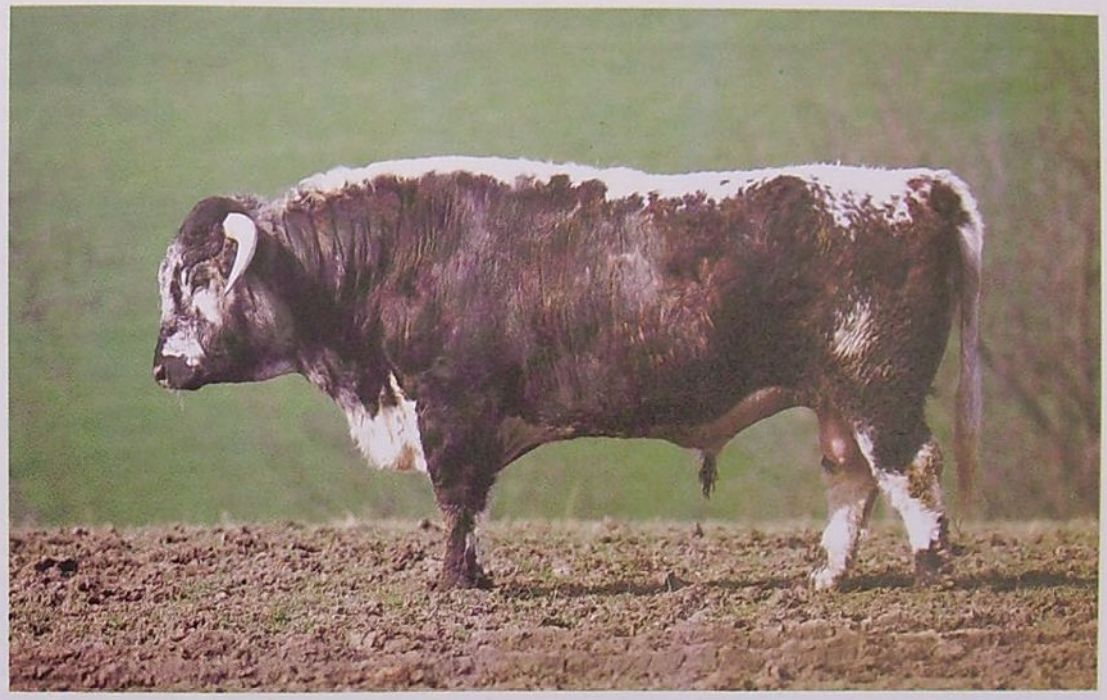
Two hundred years ago much of the beef consumed in London was derived from Galloways, Kyloes and Welsh Blacks, shoed for the road and driven all the way from

Scotland or upland Wales to be 'finished' on the fattening pastures of the Vale of Aylesbury. Today these picturesque upland cattle have acquired decorative value, and they are often grazed on parkland which could support more productive, but less handsome breeds.

Upland beef today On the hills, calving is timed for the spring to miss the worst of the winter. The calves are reared naturally by their mothers, a system known as 'single suckling' (one calf per cow). This enables the cows to roam over the poor grazing, and makes the most of a milk yield which is too low to justify investment in milking equipment.

In the milder hill farming areas, this principle is employed in conjunction with cross-breeding to produce big, beefy calves with a high market value. Hybrid 'suckler cows', chosen for their hardiness and reasonable milk output, are mated with a bull from a heavyweight lowland beef breed. The calves inherit much of the bull's beef quality, and benefit from their mothers' ability to turn poor pasture into milk. The system is identical to that used in the sheep industry to breed fat lamb.

Traditionally, the favoured hybrid suckler cow is the Blue-grey, a cross between a Galloway cow and a white Beef Shorthorn bull. The Galloway provides the hardiness,



Right: A Longhorn bull, the first modern improved beef breed which was developed by Bakewell in the 18th century. These hardy, thrifty animals are still kept today.

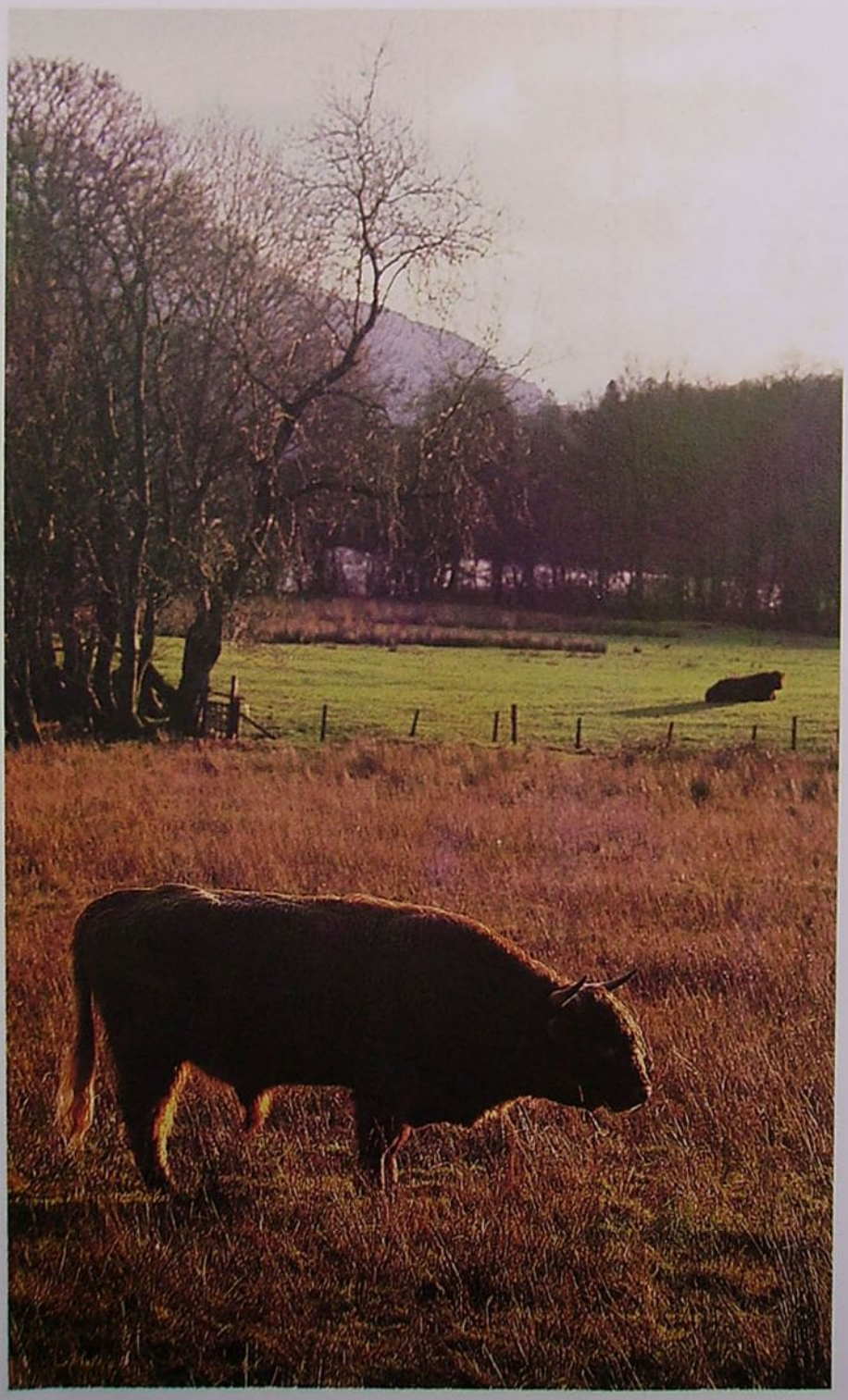
while the Beef Shorthorn, a lowland breed, improves the milk yield and growth potential. The Blue-greys are mated with a big bull such as a Charolais, producing well-built calves with a high growth rate and exploiting the excellent mothering abilities of the suckler cows to the full.

Lowland beef In the lowland areas of better soils and kinder climate this free-range style of beef farming is not practical. The land is more profitably used for dairying or arable. Consequently lowland beef breeds have been developed to achieve very high growth rates under intensive conditions, or off grass which is inadequate or surplus to the dairy farmer's requirements.

A typical grass breed is the Hereford. Run on second-rate pasture, Herefords produce good-quality meat, and plenty of it. Hardy, independent animals, requiring little in the way of special care or feeding, they are ideally suited to ranching systems, and the breed has enjoyed great success on the grasslands of North and South America.

The black Aberdeen Angus, in contrast, is a breed developed for feeding intensively on the by-products of arable farming. Before arti-

Below: Highland cow grazing near Loch Lomond. The beef from these animals is of excellent quality, and earns a premium in the shops, but with their small frame size and slow growth rate there is not much of it. Their main economic value is their capacity to thrive under climatic adversity and make use of poor pasture which most cattle breeds would not look at. Brought down off the hills into better conditions their growth rate improves.



ficial fertilisers came into general use every arable farmer counted among his capital equipment a yard full of bullocks, the purpose of which was to provide manure for the crops. Lavishly fed bullocks produced the best manure and so the farmer was well-advised to choose animals which turned a proportion of hay, grain, roots and imported oilcake into high-quality beef. Breeds like the Aberdeen Angus were ideal; properly cared for they develop into solid, square-cut beasts, all muscle. Today the bullock-yard system is out of date, but the ability of these animals to gain weight quickly under such conditions is still exploited by intensive beef producers. The cattle are bought young, kept indoors and fed a high-value diet to achieve maximum growth rate and to be 'finished' in the shortest possible time, often at less than 12 months old.

The profitability of intensive beef relies on cheap feeds, and at times of high grain prices the system is uneconomic. Consequently many lowland beef producers prefer a semi-intensive arrangement which employs grazing, home-grown forage crops, hay and straw, but is designed nevertheless to keep the animals growing well from weaning to finishing at the age of 18 to 24 months. In this respect it differs from the traditional beef fattening system, in which animals are reared on a minimum, or 'maintenance' diet on the farm where they were born, and eventually sold as 'store cattle' for finishing on a farm with surplus grazing or preserved fodder.

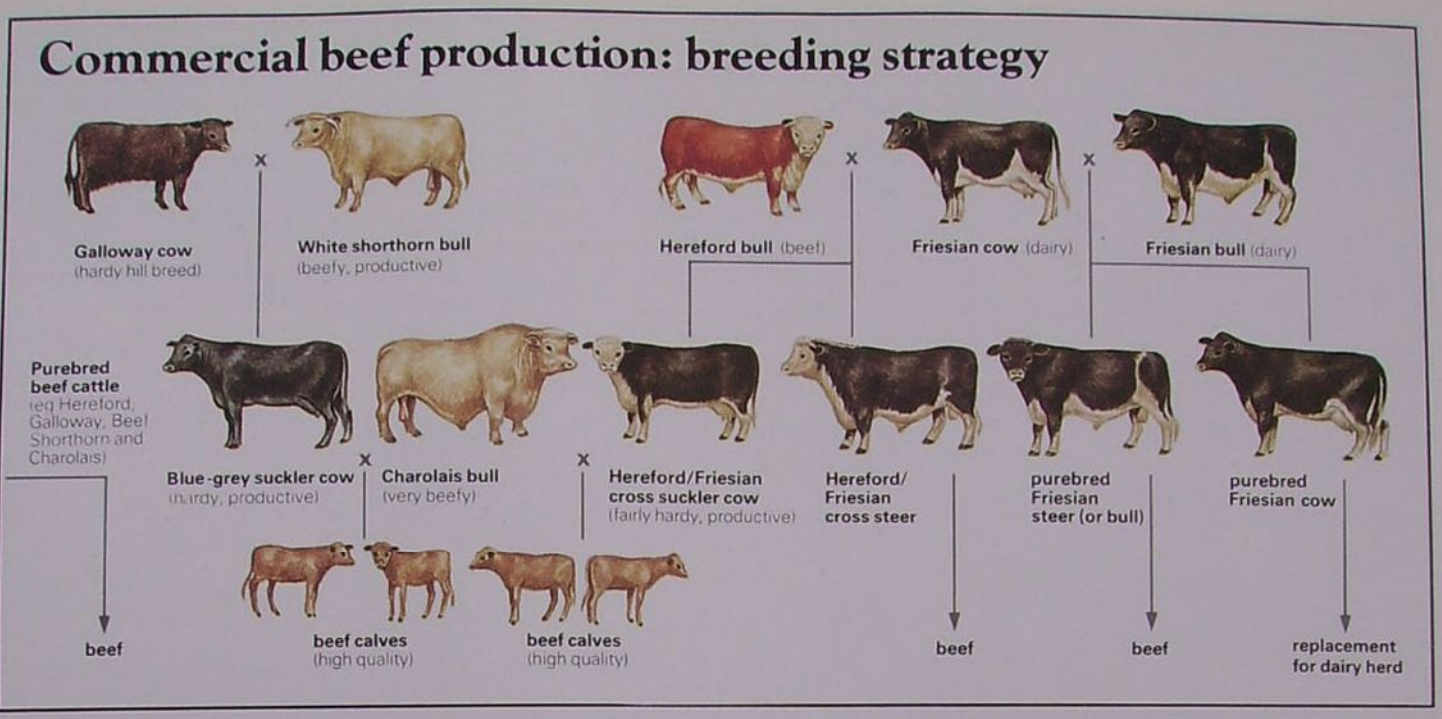
The economic margins on all these lowland systems are narrow, and using expensive pure-bred beef breeds such as the Hereford and the Aberdeen Angus does not help. In fact, most of the beef stock in Britain today is derived from a much cheaper source: the surplus of a flourishing dairy industry.

Dairy surplus Dairy cattle do not, in general, make good beef animals; they are normally too gaunt and bony, having been selected over the years for their ability to divert energy into milk production. To give milk at all, however, a dairy cow must have a calf every year. She may be mated to a bull of the same breed to produce replacements for the dairy herd but many farmers prefer to buy their replacements, and mate their cows, with a beef-type bull to produce crossbred beef calves. These animals are fast-growing, fairly hardy, and economical to feed; they respond well to both traditional and intensive management, and their meat, although inferior to that of the purebred beef breeds, is lean, abundant, and well suited to the supermarket pre-pack trade.

Most beef enterprises today rely on these animals, and the market for purebred beef calves for fattening has contracted. The crossing system has, however, created a lucrative market for beef bulls, and bull breeding has become the main concern of many pedigree herds.

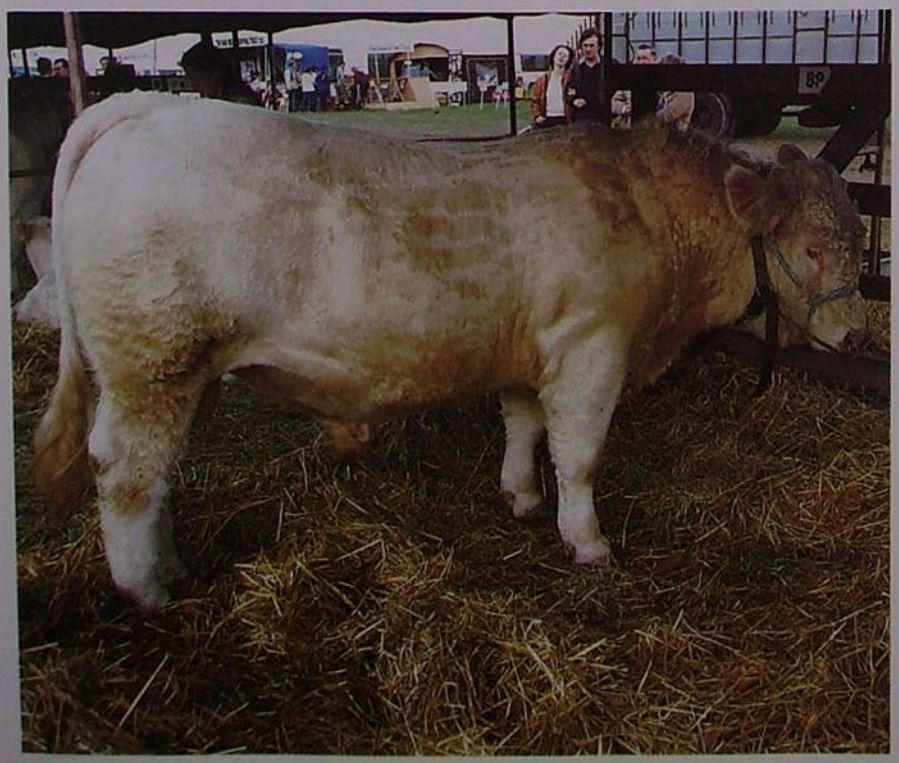
Bull breeding Currently the most popular crossing bull is the Hereford. Mated with a dairy cow such as a Friesian it sires a meaty, quick-growing calf which fattens up well off grass and cheap fodder. The calves inherit the white face of the Hereford, a useful feature since it allows the beef calves to be easily distinguished at birth from their dairy cousins, and reared accordingly. Buyers like them too; they can see at a glance what they are paying for. Female calves resulting from the match are often sold to hill farmers for use as suckler cows in areas where the hardiness of the Blue-grey is inappropriate.

Aberdeen Angus bulls also colour-mark their offspring, the calves inheriting the all-black pigmentation. The Angus is often used



Above: This chart shows the breeding strategy used to produce beef in the British Isles.

Below: A Charolais bull. This big, heavily muscled Continental breed, like the Limousin, sires a large calf. Such bulls are best used on the bigger breeds of dairy cow. The calves are correspondingly more valuable and their excellent response to high feeding levels makes them popular with intensive beef units.



on the smaller dairy breeds such as the Jersey, for being a relatively compact animal it sires a small calf, minimising calving problems.

The dairy farmer who breeds his own replacements for the milking herd must use a dairy bull. Often the cows are artificially inseminated but usually, however, the dairyman keeps a real bull on the premises in case some of the cows do not respond to the artificial variety. This is generally a beef bull, for a crossbred calf is of more use to the farmer than a second-rate dairy calf. This is the reason why one often sees mixed batches of calves.

The problem with dairy breeding is that, inevitably, half the purebred calves will be male. If both parents are of exceptional quality, a male calf may be reared as a breeding bull, and sold for a fat sum. This, however, is unusual; most of the bull calves end up as beef, and since the beef quality of many of the specialist dairy breeds is poor, they fetch a correspondingly poor price.

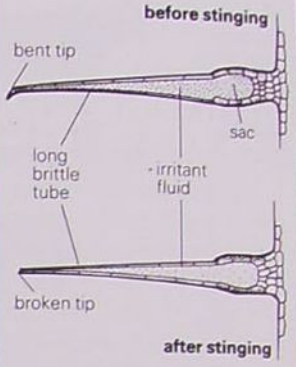
Dual-purpose animals The early cattle breeders, mindful of this, attempted to breed dual-purpose animals which could be fed for milk or beef production as required. The results were disappointing, and with a few exceptions most British dairymen, by the mid 20th century, were using cows selected for milk yield, and employing crossbreeding to ensure a market for their calves.

In recent years however the black and white British Friesian, a high-yielding dairy breed, has been developed for beef. The animals are big-boned and fast-growing, and although their meat would not tempt the connoisseur, it is lean, attractive and marketable. This is a reason why the Friesian is so popular today. Its dual-purpose character may be threatened, however: a Canadian strain of the breed known as the Holstein, notable for its milk output but not its beef quality, has been widely used recently to upgrade the dairy output of Friesians, to the detriment of their beef potential. It remains to be seen how far this process may be taken, and whether the dual-purpose concept will be abandoned yet again.

One development which may forestall this is the growing interest in bull beef. Normally male calves reared for beef are castrated to make them more manageable. Such animals are known as bullocks or steers. The disadvantage is that the hormones which make a bull aggressive are also responsible for its high growth rate–faster than that of a cow or a steer. Another option is the growth hormone implant. But these methods only improve the beef's quantity, not its quality.

Left: Nettles are especially partial to disturbed soil rich in nitrogen and phosphorus, and so favour sites that have been worked and then abandoned by man, such as hedgebanks, rubbish dumps, odd corners of gardens and so forth.

The sting



A close-up view of a stinging 'hair' shows it to consist of a swollen sac and a long brittle tube filled with irritant fluid. When brushed against, the tip snaps off and the tube and irritant penetrate the skin.

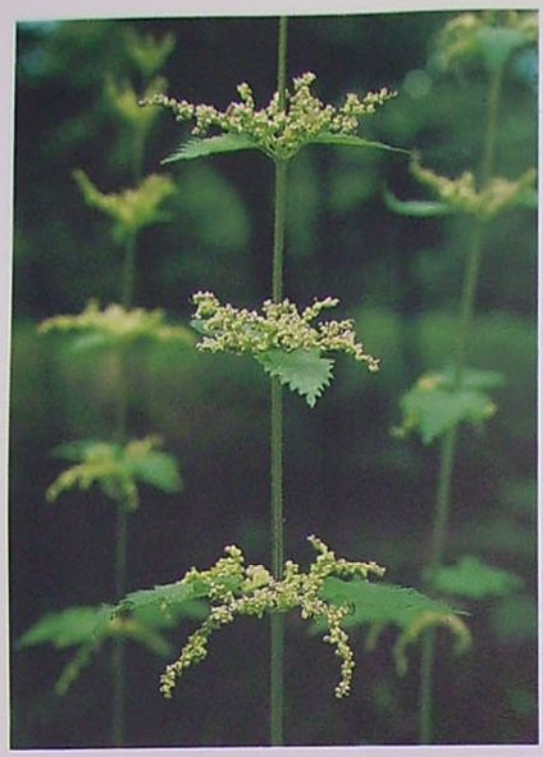
THE WORLD INSIDE A NETTLE BED

From early childhood we all painfully learn to recognise and avoid beds of stinging nettles, as indeed do many browsing mammals. Insects and small birds, however, view nettle beds in a very different light–impervious to the sting they regard them as excellent places for feeding and breeding.

Below: Several species of moth lay their eggs only on nettle and its close relatives: the snout moth (shown here), the nettle-tap and the burnished brass, and also two species of spectacle moth. Moth caterpillars on nettle are easily distinguished from those of butterflies by their lack of spines and by the fact that they never live in communal webs (though they may roll leaves together for pupation).

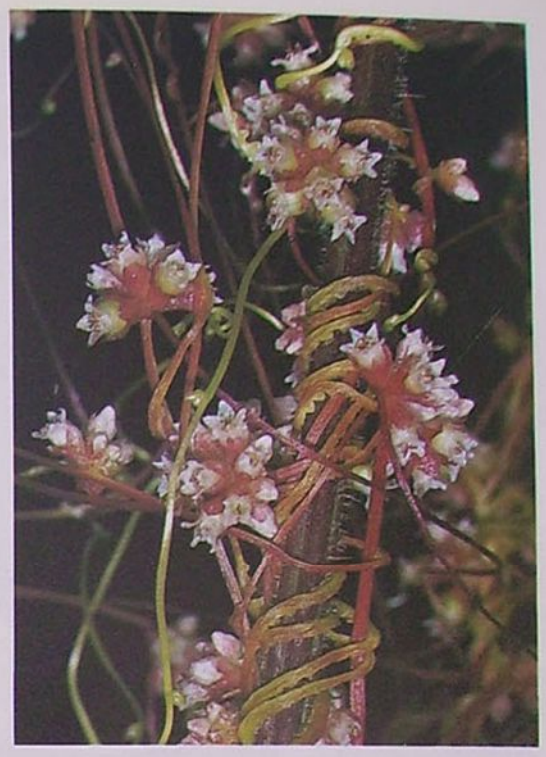
The nettle is a robust long-lived plant belonging to an order of plants called Urticales, which includes some well-liked species such as hop and elm. There are two kinds of true nettle (as opposed to the unrelated dead nettles) in Britain–the stinging nettle (*Urtica dioica*) and the small nettle (*Urtica urens*). The latter stings just as painfully as its commoner relative but it has a much more localised distribution and is much less well known.

Stinging hairs The sting of the stinging nettle comes from so-called hairs that liberally clothe the stems and leaves (though they are absent from the flower heads and the base of the stems). A good hand lens reveals each 'hair' to consist of a swollen sac filled with irritant fluid and a tapering tube, bent at the



Left: The flowering time is late May and June, male and female flowers being borne on separate plants (hence the specific name *dioica*, which comes from the Greek for 'two houses'). Both male and female flowers are borne in long drooping inflorescences and are difficult to tell apart at a distance. Close to, however, the individual male flowers bear four stamens which makes them more conspicuous than the female flowers.

Right: The parasitic plant, greater dodder, entwines itself around the stems of nettle and sends out fine rootlets to penetrate the stem and absorb nutrients. Though it does its host no good, dodder adds a certain colour to a nettle bed.



Above: A garden warbler nesting among a thicket of brambles and nettles. Various warblers and other small birds nest and feed in nettle, and must take a heavy toll of its insect life. Nettle beds are excellent places for small birds to nest and feed because, as well as providing them with a source of food, they also offer the birds protection against predatory mammals such as stoats and weasels–for the nettle's stings provide an equally good defence against predators as they do against browsing mammals.

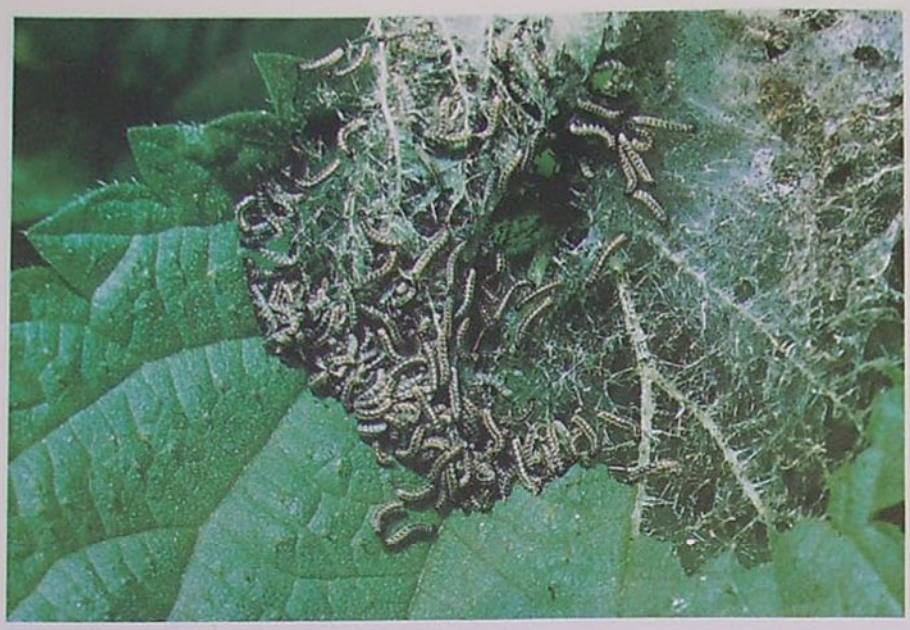
tip, whose walls are stiffened with silica and are thus as brittle as paper-thin glass. The mildest pressure fractures this tip, enabling the needle-sharp tube to penetrate the skin and discharge its fluid like a hypodermic syringe. In former times the irritant was thought to be simply formic acid but recent research has shown it to be a highly complex brew of chemical agents which have local effects on our nervous and muscular systems.

Worldwide distribution The stings undoubtedly provide effective defence against browsing animals like cattle and rabbits which, with sensitive snouts, shun nettle, and this immunity to many mammalian browsers has helped it to become one of the most widespread plants in the world. It grows from the Mediterranean through temperate zones to the Arctic, though is absent from the tropics. In Tibet, for example, it thrives up to 3000m (10,000ft) and in Britain up to 750m (2500ft), notably in the Scottish Highlands.

Nettles are probably native in Britain to fen carr and perhaps pedunculate oak woodland, though they flourish on most soil types except acid peat. They are especially partial to disturbed soil with a high nitrate and phosphate content, and so favour ground that has been worked and abandoned by man. On high ground the presence of nettles is thus a good indicator of former human settlement. In the Highlands it often betrays the site of an old croft, or the rotted remains of an animal carcase. More sinisterly its presence in remote areas has sometimes been attributed to the burial sites of humankind. A great opportunist, nettle may also establish itself on shingle banks above the tideline.

Means of dispersal The nettle is well adapted for rapidly exploiting these varied sites, for it has two means of spreading–by seeds and by perennial rhizomes. The aerial stems sprout from a branching network of rhizomes which may grow up to 50cm (20in) in the course of a year. Once a nettle patch is established, these rhizomes account for most of its subsequent spread. To the consternation of gardeners who cut down the summer's aerial growth, the underground system habitually sends up healthy new shoots in late summer and autumn; these may successfully withstand the harshest winter to sprout in spring, replacing the dieback of older stems.

Come late May and June, those nettles in their second year bear heads of either male or female flowers, rarely both on the same plant. The coiled stamens of the male flower straighten out explosively on warm summer days to release puffs of greenish yellow pollen in prodigious quantities. An average male



plant may produce about 45 million pollen grains which are dispersed mostly by the wind, producing a high fertilisation rate of female flowers.

Insect life The long growing season, perennial habit and dense growth make the stinging nettle much more attractive to insects than the small nettle which, being a more localised annual, is less suitable for supporting the variety of insect life-cycles. Most of the insects found on nettles exploit the sap and tissues, and seem to be unaffected by the stinging hairs. The commonest groups are plant bugs, various homopterans such as leafhoppers, froghoppers and aphids, and moths and butterflies, as well as several flies and beetles.

Some insects have developed a life-cycle dependent specifically on nettles; some co-exist with both nettle and its relatives, while numerous others pause only briefly in nettle beds before moving on to some quite unrelated plant. Many of these passing visitors, notably certain beetles, flies and spiders, are wide-ranging predators, attracted to nettles by their rich fauna of potential prey.

Butterflies and moths The best-known and most obvious associates of the nettle are butterflies. Four species, all belonging to the family Nymphalidae, feed exclusively as caterpillars on nettle or its close relatives. The peacock and small tortoiseshell butterflies are among the first seen each year; this is because most adults of the late summer hibernate and are coaxed into activity on warm March days. After mating, eggs are laid in batches on the underside of nettle leaves. The females choose their nettles with care, apparently preferring small isolated patches regularly warmed by the sun to extensive beds in damper, shadier sites. The eggs hatch into a colony of blackish caterpillars which spin a silken tent as safe anchorage and then fuel their growth by collectively devouring the leaves around them. As they grow, the caterpillars develop spines which make them rather unpleasant eating for small birds, but cuckoos, which

relish all sorts of hairy caterpillars, feed on them in late June and July. When fully developed, the caterpillars forsake their commune and pupate separately. Red admirals and comma butterflies, also in the family Nymphalidae, lay their eggs singly on the upperside of nettle leaves, and the caterpillars lead a solitary life from the outset.

Several species of moth caterpillar lay their eggs only on nettle and its relatives, and various others, notably the 'woolly bear' of the garden tiger moth, also regularly occur on nettles.

After mid-June, when the tree canopy is largely devoid of caterpillars, tits may forage in nettle beds for the less noxious species; in one study a camera mounted behind a nestbox showed that great tits sometimes brought caterpillars of the snout moth (which feed only on nettles) for their young. Various warblers and other small birds also nest and feed in nettle beds, and must take a heavy toll of its insect life.

Miners and suckers While caterpillars of butterflies and moths devour nettle leaves wholesale, other insects adopt a more subtle approach. The larvae of some flies belonging to the family Agromyzidae eat their way inside the tissues of the nettle, creating 'mines'

Above left: The small tortoiseshell (whose caterpillars are shown here) is one of four species of butterfly to feed exclusively on nettles. The adults lay their eggs on the undersides of the leaves.

Above: Although the caterpillars feed communally they pupate separately. Here an adult small tortoiseshell is emerging from its chrysalis and (left) the same adult about an hour later.

Key to species

1 Nettle aphids feeding on the flowers and leaves.
2 Caterpillar of a garden tiger moth on a stem.
3 Seven-spot ladybird on a leaf.
4 Blue tit perching on a stem.
5 Cuckoo spit froth at the joint of a stem and a leaf.
6 Leaf rolled by a mother-of-pearl moth
7 Mined leaf caused by *Agromyza anthracina*.
8 Comma butterfly basking on a leaf.
9 Nettle midge galls.
10 Hoverfly on a leaf.
11 Encrustation of nettle ground bugs around the stem and leaves.
12 Eggs of the comma butterfly on the underside of a leaf.
13 A species of weevil on a leaf.

Life among nettles

in the leaves or stem. One of the best-known species bores winding mines between the leaf veins. Nettles are also regularly attacked by the widespread nettle midge whose larvae, often many to a single plant, make small glossy brown galls on the veins of the leaf, usually near the leaf base, and also occasionally on flower stems.

The activities of mining and gall flies pale into significance, however, compared with the many insects (about 50 known species), which suck the nettle's sap. Some, like the aphids, psyllids, and froghopper larvae (which produce the familiar 'cuckoo-spit') tap the nettle's main vessels, while various bugs, leafhoppers, and thrips species suck individual leaf cells, producing a tell-tale pale stippling effect.

Of these 'pests' the most important are the small and large nettle aphids, capable of multiplying spectacularly through a rapid turnover of successive generations. The small nettle aphid thus proliferates through two generations which look and behave quite differently: in spring, dark green or blackish forms crowd along the nettle stems, while the smaller yellowish summer generation disperses itself more discretely along the veins on the undersides of leaves.

Clearly no part of the nettle is likely to be immune from exploitation by insects: the pollen is harvested by various flower beetles, and even the fibrous rhizomes provide a diet for larval weevils. Thus, the apparently well-guarded nettle is, on closer inspection, a reservoir of insect life.

LICHENS IN THE CITY

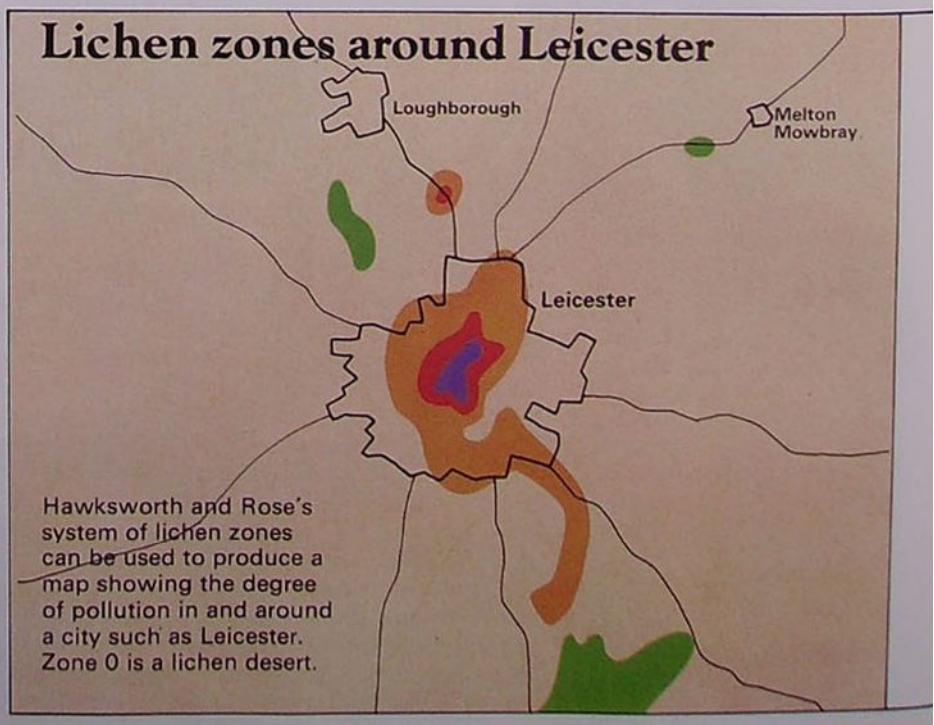
After centuries of decline lichens are now beginning to make a comeback in our towns and cities–a sure sign that our air is becoming cleaner.

It has been realised for more than a century that lichens are much rarer in towns and cities than in the countryside. The first proper study was carried out in Paris, and it was declared that the small number of lichens was due to the production of dark smoke and gaseous emissions, which made the air unsuitable for their growth. This view is still generally accepted today, though the dryness of town air is now thought to be another important factor.

Lichen zones In the 1920s a botanist, Johan Sernander, introduced the concept of lichen zones. He recognised that there are three zones of lichen development in towns. In the centre, and around gasworks, railway stations (with steam trains in those days) and large industrial plants, there was a lichen desert. In the outer part of the desert the barks of trees began to be covered with green algae–only on stones were a few solitary lichens to be found. The next zone was a 'struggle zone' where the tree trunks were beginning to be colonized by lichens, though they were not abundant.

Above: The best place to look for lichens in a town is old churchyards, where you can sometimes find relict lichens growing on the headstones. Shown here is the relict lichen, *Caloplaca heppiana*.

Left: Dark patches of lichen discolouring a street monument in Kettering, Northamptonshire.



Hawksworth and Rose's system of lichen zones can be used to produce a map showing the degree of pollution in and around a city such as Leicester. Zone 0 is a lichen desert.

Rocky outcrops had a denser lichen cover. In the third zone the lichens were abundant on both trees and rocks.

Sernander's work led to the idea of using lichens and zones of lichen species as indicators of air pollution. The chief scale used today was devised by David Hawksworth and Francis Rose in 1970. Based on epiphytic lichens (ones growing on trees) their system recognises 11 zones ranging from zone 0, in which there is a complete absence of epiphytes, to zone 10, which contains species requiring very clean air. Maps of several towns and cities have now been produced showing the pattern of the zones.

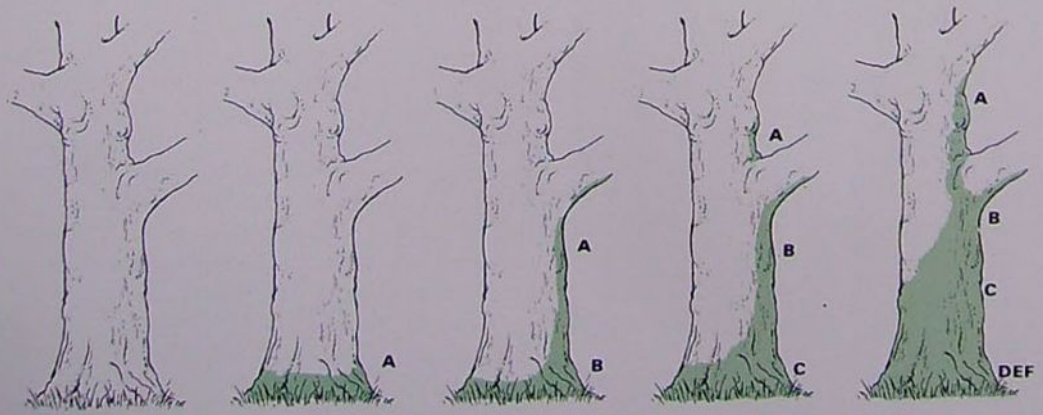
Where to look The types of urban lichen that have been most studied are the ones growing on barks, because of their importance as indicators of air pollution. Yet lichens on other substrates are much better represented in urban areas. Calcareous stone, such as limestone, is the most important, with two-thirds of urban lichens occurring on it. The richness of the lichen vegetation on this substrate is due to the alkalinity of the stone, which indirectly reduces the toxic effects of sulphur dioxide–a major consituent of polluted air.

Asbestos-cement roofs have a particularly rich lichen flora–again because of their alkalinity, and also because of their ability to absorb water and their fibrous texture. These roofs have become particularly widespread on factories and garages built since World War II, but they are now in decline following the recent concern over the dangers of asbestos. (For this reason, any lichen studies you may carry out on asbestos-cement must be done with great caution.)

The best places to find lichens in towns are usually old churchyards, especially those with limestone headstones manured by birds. Here you can often find 18th century headstones with relict lichens on them. These lichens would have colonized the stone a long time ago but, because of the modern level of air pollution, are unable to spread to new surfaces. One such relict is *Caloplaca heppiana*, which forms orange rosettes with lobes at the edge and fruiting bodies in the centre; it is confined to stone buildings and monuments built before the present century.

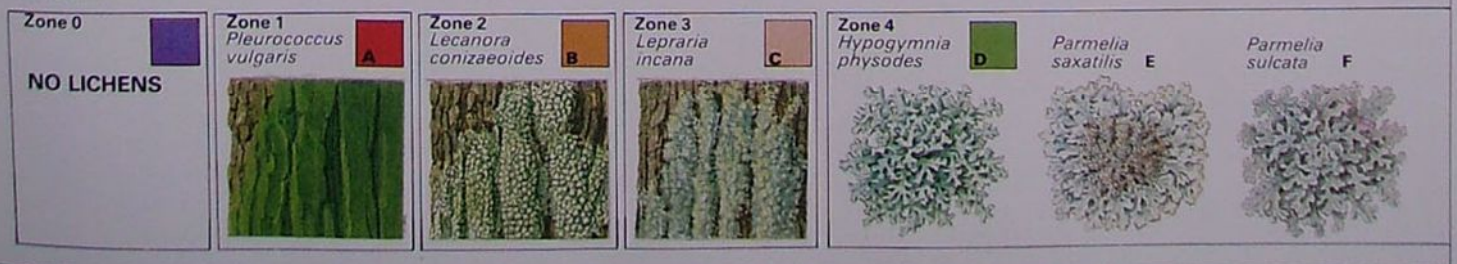
The most impoverished habitat for lichens in towns and cities is trees and woods. In many towns, fewer than ten lichen species occur on tree bark. Grassland is also poor in lichens, probably because of the combined effects of trampling and mowing, as well as the effects of

Below: The major cause of lichen deserts in cities is the presence in the air of sulphur dioxide, which is produced by the burning of coal and as a waste product in many industrial processes. Conditions are not necessarily as bad as they seem, though; in this picture, taken in north London, the chimneys on the left are emitting poisonous sulphur dioxide while the pair of large cooling towers on the right are producing only harmless steam.



The zones

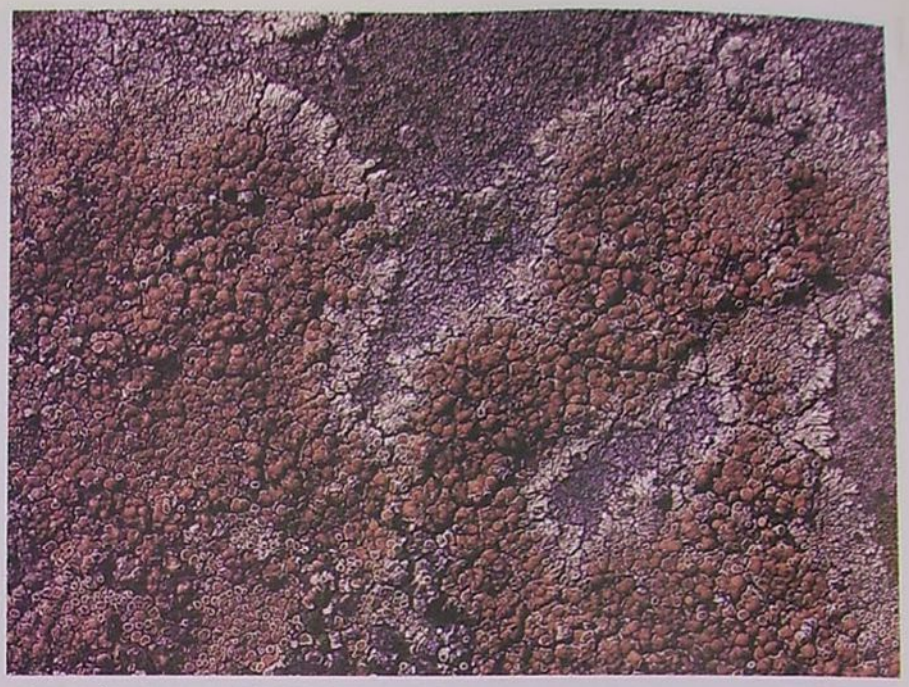
In **zone 0** the trunks are bare of lichens. In **zone 1** green algae grow at the base, and appear higher up in **zone 2** with *Lecanora conizaeoides* coming in at the base. In **zone 3** this lichen grows higher up with *Lepraria incana* at the base, and in **zone 4** foliose lichens come in at the base.



air pollution.

Lichens to look for Despite the general poverty of urban lichens, several species are now more common in towns than in the countryside. These are small fast-growing lichens, which tend to be crowded out in rural areas by larger species. Included among them are *Lecanora conizaeoides, Lecanora dispersa, Candelariella aurella, Lecanora muralis* and *Stereocaulon pileatum*. All these species are of particular interest–to consider them one by one: *Lecanora conizaeoides,* also known as the pollution lichen, was unknown in Britain before 1860 yet ten years later it was becoming widespread. It increased rapidly with the general rise in levels of air pollution around this time and is now common in both urban and rural areas of England, Belgium, the Netherlands and northern Germany. It can be seen on the bark of trees, the wood of fences and the clay tiles of roofs. It forms a powdery grey-green coating and looks rather like a green alga, though the latter is a brighter green.

Lecanora dispersa is very variable and unusually forms a white or greyish-white crust, though in city centres a black form occurs, disfiguring white limestone and cement. *Candelariella aurella* is another dark lichen that disfigures buildings. The two can be distinguished by their fruiting bodies. On the *Lecanora* species they are whitish and on the *Candelariella* species they are yellow.



Above: *Lecanora muralis,* one of several lichens now beginning to colonize urban habitats. This species is found on concrete paving stones and on asbestos-cement roofs.

Below: Grey-green patches of *Lecanora conizaeoides* alongside a green alga.

Lecanora muralis is a greyish-green to greenish-brown lichen widespread on rocky outcrops and now abundant in towns, forming circular patches on asbestos-cement roofs and concrete paving stones. Its colonization of pavements in recent years has caused some concern. One local London paper reported that residents feared the lichen might be dangerous to health and destroy property. It is, of course, quite harmless.

Another recent colonizer of towns is *Stereocaulon pileatum*. Before 1950 this lichen was confined to acid rock outcrops on mountains and was quite scarce, yet today it is colonizing walls in towns and cities at a surprising rate–it particularly favours garden walls built of slag.

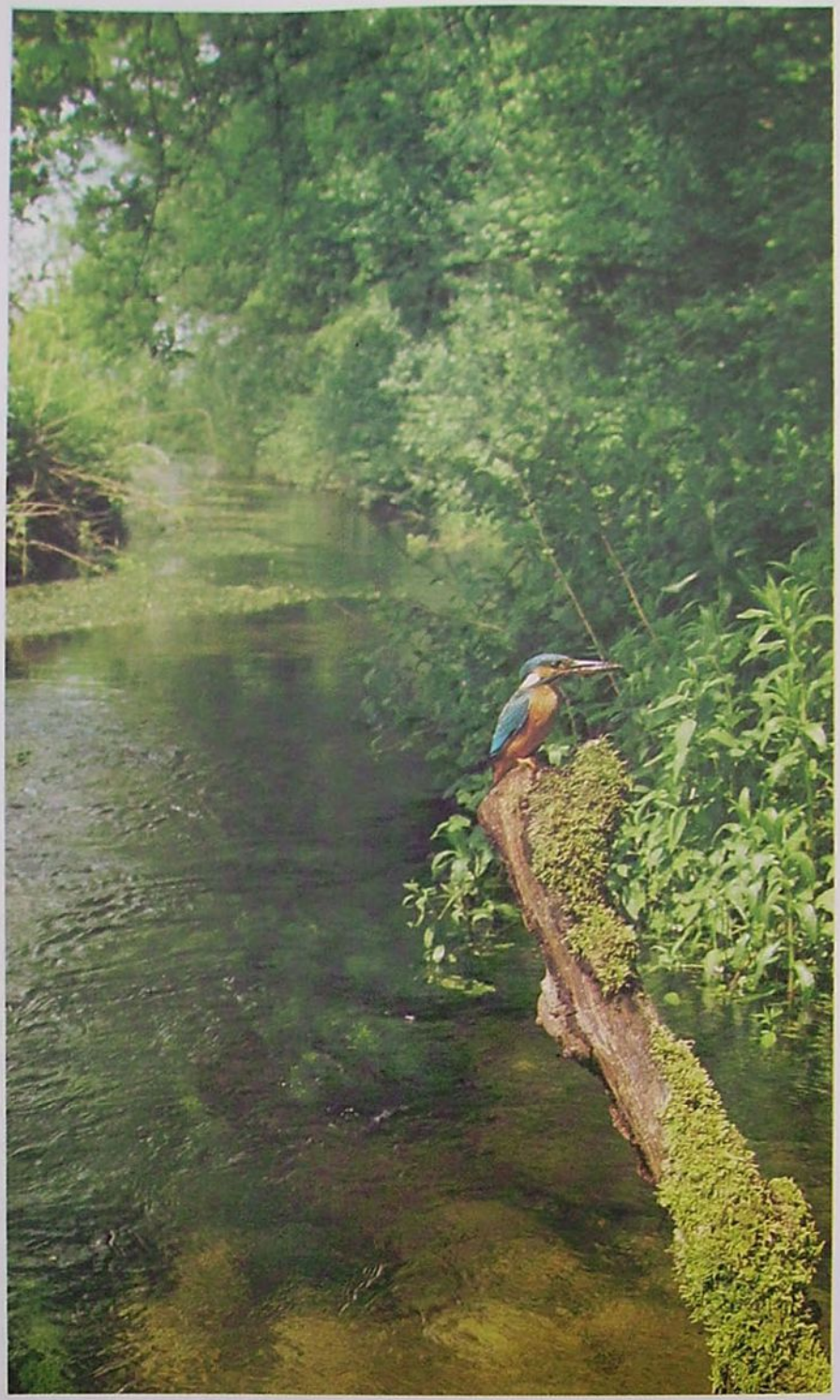
Encouraging signs The passing of the Clean Air Act and the establishment of Smoke Control Areas in which coal burning was banned have, in recent decades, led to a dramatic fall in the amount of smoke in the air.

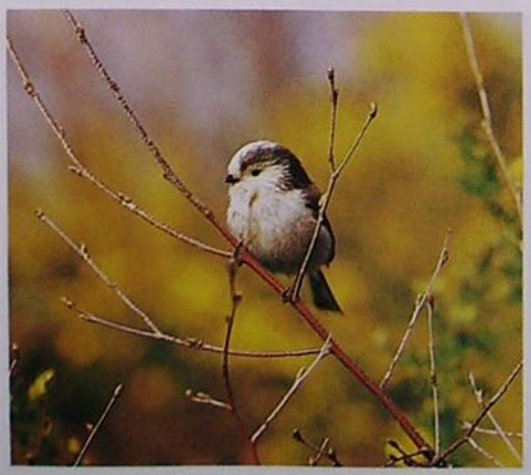
The chief form of pollution affecting lichens, however, is sulphur dioxide, and this too has declined, though less spectacularly than smoke. Nevertheless, the level of this gas in London's air halved between 1962 and 1974, and lichens are enjoying the benefit of this reduction. Small plants of *Hypogymnia physodes* are now colonizing willow trees on Hampstead Heath in north London, where they have been absent for more than a century. South of the Thames a specimen of beard-moss (*Usnea*)–actually a lichen–has been found growing on a willow in Richmond Park. This lichen has not been seen in London since the 18th century.

As yet there are no festoons of lichens hanging from the trees of Hyde Park–for this to be possible much more vigorous efforts are necessary to reduce the levels of sulphur dioxide in the air. Yet, even without these measures, the slow return of lichens to our towns and cities seems assured.

BIRDS IN SPRING: A NEW START

The frosts are over, and food is plentiful: you can see signs of new energy and excitement in bird life, as the breeding season draws near.





Above: A kingfisher holds its catch, with the new leaves of spring all around. This is one of the bird species most likely to find spring an enormous relief, for iced-over rivers and lakes spell starvation for the kingfisher. Another bird that has done well just to survive into spring is the long-tailed tit (left). It is one of the small insect-eating birds that suffer severely from chilling, and may have difficulty collecting enough insects to keep warm enough to survive.

For many bird species, the beginning of spring is an easy time of year and a welcome relief from the savage influence of winter. Ice no longer freezes up the food supply, whether it be invertebrates in the soil or fishes in the water. Darkness, cold and damp are on the decline, and with easier foraging there is more time to enjoy the sunshine. At the same time, while this is true for the majority of birds, there are a number of species for which a mild winter, at least, is the easiest time of all. Mallard and the small gulls, for example, can often be seen enjoying very leisurely days in mild winter weather. Their food is abundant and it is easy to collect a day's supply in, say, an hour; no time has yet to be devoted to pairing or breeding activities; and so even the short daylight period of winter has to be whiled away with long roosting and preening sessions on quiet lakes. But they are the exceptions, not the rule.

Buds, flowers and insects One of the first beneficiaries of spring is the bullfinch, whose sharp-edged, rounded bill makes short work of swelling flower buds from fruit trees and bushes, extracting only the nutritious central tissues otherwise destined to become flowers, and eventually fruits.

Both flowers and the insects which come to feed on their pollen and nectar provide food for birds. Attacks by house sparrows on nectar-rich crocuses (most often yellow) and plum blossom are perhaps the best examples of the first. As for the insects that flowers attract, birdwatchers always make a point of visiting ponds, lakes and other damp areas from the beginning of March onwards, for in these places the pussy willows flower at this time. Here you can count on seeing the first chiffchaffs and sand martins to return from southern Europe and North Africa.

Seed eaters Of all land birds, it is probably the seed eaters which benefit last from spring, for fresh seeds must, by definition, follow some time after the flowers. For some species, such as the greenfinch and siskin, early spring is therefore the time of greatest food shortage, and this explains the high frequency of spring visits to peanuts in gardens by such birds.

The dawn chorus Song and display provide

Sights and sounds in spring

Song thrush

Dawn chorus: the first half hour of a spring day is often astonishing for the sheer volume of birdsong.

Feather abrasion: by late February the male chaffinch's head feathers have worn into breeding colour.

House sparrow

Feeding on flowers: to birds, certain flowers can be particularly nutritious–like these yellow crocuses.

Swallow

Migrant arrivals: as soon as flying insects become plentiful, Britain is habitable for swallows.

Above: A sedge warbler singing among newly opened willow leaves, soon after arrival from migration. Birdwatchers find willows and sallows rewarding trees to watch at the start of spring, largely for the sake of sights–and sounds–like this.

clear and effective communication between individuals of the same species–essential if the available resources are to be shared between adjacent pairs without resorting to mass fights. Britain has a number of excellent songsters including some, like the song thrush and robin, which can be found even in city centres. In the dawn chorus, each aspiring territory-holder declares his presence to all who listen.

These loud exchanges travel farthest on cold, calm mornings when a temperature inversion forms (when a layer of cold, dense air is topped by warmer, light air), since some sound waves are reflected back towards the ground instead of passing up into the atmosphere. Such conditions therefore prompt the greatest number of birds to partake in the dawn chorus. Birds also sing in a chorus at dusk; another reason for singing at these times may be that the early or late hours of daylight may be too gloomy for feeding.

Return of the native As a general rule, birds keep or reclaim the same territories in successive years whenever possible. This is hard to prove since different individuals usually look so alike, but it does explain the recurrence of particularly tame robins, or blackbirds that are recognisable by their complete or partial albinism, in the same garden for several years running.

Furthermore, ringing studies have shown that even migrants return each year to exactly the same spot. Given that they themselves were bred successfully, it is quite logical that they should return to breed in their native locality. On the other hand, even adjacent territories may vary considerably in their 'suitability', so some jostling for the best position can be expected.

Coming into plumage Breeding plumage, so important in displays and mate selection, is often most marked in spring, and to achieve this some species, like the ruff, grow feathers specially for this purpose in late winter and early spring. At their communal lekking grounds their extraordinary colours are displayed to the full. Other species retain their breeding plumage all year round–the black grouse, for example, another species with remarkable communal displays, moults only in autumn each year.

Still others make effective use of feather abrasion, the process whereby the tips of feathers wear away during the winter months. The male chiffchaff is one such species: when first grown (in autumn), his head feathers are broadly tipped in buff, and only when the buff tips have worn away is the blue-grey breeding coloration visible.

The earliest eggs The task of laying eggs and rearing young is essentially a summer activity, but some species regularly reach this stage of the breeding cycle before even March has ended. Mistle thrushes sometimes lay eggs at the end of February, and their peak laying

Below: The male bullfinch is one of the perennial delights of spring, with a bold display of black, wine-red and grey plumage–and a flashing white rump.

Starling

Nest building: the male starling starts building a nest early in April, before it has found a mate to occupy it.

Siskin

Garden visitors in spring: siskins tend to run short of seeds in the wild, and turn to garden peanuts if available.

Common terns

Mating begins: common terns return to their colonies, pair and mate. Eggs are laid only a few days after mating.

season is the end of March and early April.

However, the earliest nesting attempts of each bird species often fail, either because of subsequent cold weather, chilling the eggs or nestlings, or because there are too few leaves at this time to conceal the nests from predators.

Flying north Many species of birds migrate from, through or to the British Isles in spring. Departures of winter visiting birds, like redwings and fieldfares, may easily go unnoticed, and recording last dates of sightings requires studious, ideally daily notes of birds seen.

Perhaps even more easily missed are departures of numerous finches, starlings and other small birds which swell the resident numbers here in winter. Many seabirds, waders and wildfowl also head north from our coasts, and from inland wetlands, to their breeding grounds inside the Arctic Circle.

Arriving from the south Arrivals of summer visitors are more easy to see and record, and it is an interesting exercise to compare first dates of different species. Among the earliest are the chiffchaff, swallow, sand martin, wheatear, Sandwich tern and black redstart, while the swift and spotted flycatcher arrive very late–rarely before the end of April. Males often precede females, and adults usually precede juveniles, so that, for example, the first yellow wagtails are conspicuously bright yellow, while later birds of the same species are more brown. Most migrants, eager to set up territory, fly direct to their breeding grounds, but a proportion, tired from the journey, land as soon as the opportunity arises.

For this reason coasts, especially in the south, are always worth a look in spring. Headlands, and patches of bushy scrub in otherwise open terrain, often attract a variety of species. Sea watching can be rewarding if waders like whimbrels and godwits are flying past, and you could see small passerines coming in; or perhaps a rarity such as a red-necked phalarope on its way to the Scottish Islands or beyond. Some of these exciting waders stay in Scotland for the season, but many pass through in spring and continue north to Iceland and Scandinavia.

Right: The Sandwich tern arrives among the earliest migrants in spring, at the beginning of March. This one is still in winter plumage: by the end of March it will have a shaggy black crest of feathers extending back from the base of the bill.

Below: Among British birds, the whimbrel is the curlew's northern replacement, occupying a breeding range that extends northward from Sutherland and the Hebrides into Orkney and Shetland. The migration journey is long, for the bird winters in tropical Africa. Therefore whimbrels do not reach their breeding grounds until late April or May. They are often seen breaking their long journey with stops on headlands on the southern and eastern coasts of England.

EXOTIC PLANTS OF IRELAND

Over the centuries the mild moist climate of Ireland has encouraged many exotic plants, originally introduced as ornamentals, to spread beyond the garden hedge into the countryside. Several of these exotic species are certainly unknown in the wild on the British mainland.

The flora of any island is composed of plants that were present when the island first became isolated and plants that arrived later. The Irish flora was effectively 'frozen' when the last land link with Britain and Europe was submerged, about 7500 years ago, and the Irish Sea was formed. Since that time, only plants with very light, wind-blown seeds or those with seeds capable of floating and surviving in sea water could have reached Ireland by natural means. But this is unlikely because the prevailing ocean and wind currents move from west to east, which is away from Ireland towards Britain and the rest of Europe. These historical and geographical factors have combined to enforce the isolation of Ireland's flora, and there are many fewer native plants in Ireland than in Britain.

Right: Gardening tastes have expanded rapidly in recent centuries, and ornamental plants have been imported to Ireland from all over the world. One such is the garden shrub, rhododendron, introduced during the 18th century.

Below: Rhododendrons growing alongside strawberry trees in Killarney, south-west Ireland. Before the last Ice Age, this species was native to Ireland. After its introduction by man it soon escaped from gardens and is now a familiar plant of the peatlands and old oakwoods of western Ireland, where it is considered a pest because it smothers native plants and prevents their regeneration.

However there is one other agency that could transport plants to Ireland, even after the land link vanished–human beings! The vast majority of Ireland's exotic flora is thought to have reached the island with human assistance, both deliberate and unwitting.

Herbal introductions One plant has such a strange distribution pattern that botanists believe it is an ancient introduction. Babington's leek, a wild onion, grows around Galway Bay on the west coast of Ireland, and also in Cornwall and Devon. It is very like an onion that grows wild in Spain and Portugal, and was probably brought to Ireland and Britain in pre-Christian times as a vegetable or herb. It is now established in sandy habitats near the ocean, and is never found far from villages or ancient settlements.

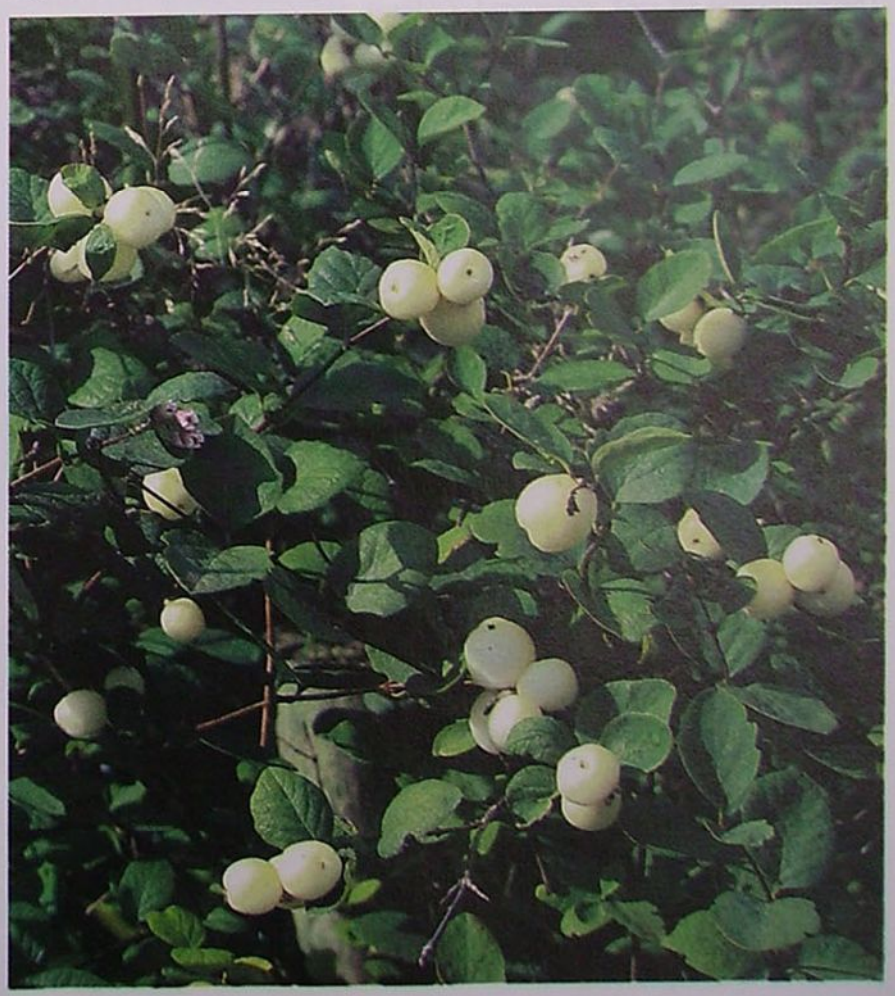
Flavoursome herbs and plants used in ancient medicines were among the earliest deliberate introductions to Ireland. Some of these now seem to be native species, but they probably did not grow in Ireland before the arrival of Christianity. It is strange that around the remains of Norman castles and towerhouses in eastern Ireland, mallow and hemlock grow in quantity, while elsewhere in the countryside these species are very occasional. Other plants associated with ancient castles and monastic sites are henbane, milk thistle and good-King-Henry.

Garden shrubs Our gardening tastes have expanded rapidly in recent centuries, and ornamental plants have been imported from all parts of the world. One of the prized garden shrubs of the last quarter of the 18th century was rhododendron from south-eastern Europe. It was carefully tended, but soon spread beyond the confines of gardens and is now a serious pest. It has colonized the peatlands of the west, and has invaded the remnants of oak woodland in Kerry, smothering the native plants and preventing natural regeneration.

A much-prized plant in gardens at the same time was the snowberry from North America. It is now distributed throughout Ireland in hedgerows, but it is not a pest like rhododendron.

South American exotics The most famous hedgerow plant in western Ireland is fuchsia. To many people it is inconceivable that such an abundant plant could be other than a true native. But fuchsia is an exotic, brought from southern South America as a garden plant. It is not known when it was first used as a hedge plant, but by the beginning of this century the fuchsia hedges of Connemara and Kerry were being eulogised in tourist guides. It does not spread by seed, except in a very few places, so all the hedges must have been planted deliberately at some stage.

Several other South American species are now naturalised, including an elegant species of myrtle, *Myrtus apiculata*, which has cinnamon-coloured bark and dark glossy leaves, and is sprinkled with white blossom in late summer. Another introduction, *Gunnera chilense*, the giant rhubarb-like plant commonly planted at the edge of ponds, is now spreading out of control in places like Achill Island and Donegal. It literally smothers native plants with its huge umbrella leaves and may become a very serious problem in years to



Below: A popular cultivated shrub in the late 18th century was snowberry from North America. The conspicuous white berries are now a familiar sight in many Irish hedgerows, where unlike rhododendron, it is not regarded as a pest.

come.

Predatory plant One of Ireland's most remarkable foreign inhabitants is the North American carnivore, purple pitcher plant. It was deliberately planted on a bog in central Ireland in 1892 but the plants died. In 1904 plants were set out on another bog near the River Shannon in County Roscommon. There it thrived, set seed, and spread. Today it has colonized many hectares of raised bog and, because of its remarkable nature, steps are being taken to ensure that the plant is not eradicated by commercial peat-cutting.

Also from North America is Canadian pondweed, which first appeared in Ireland in 1836 and soon spread to the rest of Europe.

Above: The giant umbrella-like leaves of *Gunnera chilense*. Once a cultivated plant it has now spread in parts of western Ireland.

Right: The spectacular flowers of fuchsia are a welcome part of many Irish hedgerows.

Below: A stand of purple pitcher plant nestles among heather, lichens and mosses. These unusual plants trap and ingest insects in their tall tubular leaves.

World wide We know the histories of these plants, at least in general detail, but the stories of some aliens remain mysterious. A decade ago a strange grass-like plant was collected in Connemara. It looked like a native woodrush, but was not one, and eventually the plant was identified as *Juncus planifolius*, a species from Australasia. It has grass-like leaves, unlike most of our native rushes, and reddish-brown flower heads. It is known to grow in damp places, including roadside ditches, near the tiny hamlet of Carna. But how did it get there? It is not a garden plant, and there is no natural means of transporting seeds from Australasia to Ireland! We are still puzzled.

Ireland's exotic flora contains representatives from every continent. Apart from the strange rush, there are other Australasian species, such as the dwarf willowherb from New Zealand, which has spread to the tops of the highest mountains. From southern Africa, through our gardens, came the orange-flowered montbretia that is so abundant around seaside towns. From Asia came the butterfly bush; it is now a beautiful weed in our cities.

Man is now a far-ranging traveller, and it takes only 24 hours to travel to New Zealand, for example. We import seeds and plants for gardens in huge quantities. No matter that Ireland is an island, nor that our regulations are designed to exclude unwanted pests, new plants will still come in by accident.

Irish exotica

The exotic flora of Ireland contains examples from the four corners of the world. Most have been brought to Ireland by man to serve as garden plants or for medicinal reasons. A few are accidental introductions.

Canadian pondweed (*Elodea canadensis*). First introduced to Europe via Ireland in the late 1830s.

Henbane (*Hyoscyamus niger*). Probably brought to Ireland as a medicinal herb.

Fuchsia (*Fuchsia magellanica*). A native plant from the southern parts of South America. Brought to Ireland as a garden plant.

Myrtle (*Myrtus apiculata*). A South American tree brought across for its late show of flowers.

Babington's leek (*Allium babingtonii*). Brought to Ireland in pre-Christian times from Spain and Portugal.

Montbretia (*Crocosmia* × *crocosmiflora*). A hybrid with South African parents, grown as a garden plant.

Policeman's helmet (*Impatiens glandulifera*). Also known as the Himalayan balsam. Brought to Ireland as a garden plant.

Butterfly bush (*Buddleia davidii*). Originally taken from its native China as a cultivated bush, now a common naturalised plant.

Juncus planifolius. A grass-like rush from Australia which has mysteriously appeared in Ireland.

Dwarf willowherb (*Epilobium brunnescens*). A tiny introduction from New Zealand now found even on mountain tops.

SLUGS AND SNAILS OF WOODLANDS

Britain has over 100 species of slugs and snails, and many are woodland dwellers. Indeed, some woods have more species than any other habitat.

Above: A mating pair of *Pomatias elegans*, sometimes known as the land winkle. This snail prefers the scrub of woodland edges as a habitat. Clearly visible here is the operculum used by the snail as a barrier to the outside world when in its shell.

Below: Our other species of land snail with an operculum is *Acicula fusca*. It is shown alongside the hollowed glass snail (*Zonitoides excavatus*), an example of the pulmonate group. The distinctive features here are the presence or absence of an operculum, and the position of the eyes. Shell shapes–elongated or disc-like–are not distinctive of either group.

The humidity and shelter provided by woods make them excellent habitats for a wide range of slugs and snails, and if there is a lime-rich soil permitting good shell formation then conditions may be ideal. Yet there are some woods which contain few or no slugs and snails. An example is a dense wood of fir trees with a floor of closely packed needles with no ground plants; such a wood often grows on soil with very little lime, and here you would be most unlikely to find any slugs or snails. (Slugs and snails cannot really be separated into different groups, by the way; slugs are simply snails that have a much-reduced or completely absent shell.)

Woodland slugs One of the largest slugs found in woodlands is the giant black slug (*Limax cinereoniger*), whose body can reach almost 40cm (16in) long. It lives only in woods and cannot tolerate much disturbance by humans. In wet weather it may be active by day, though it is more often hidden under logs and dead leaves at this time, coming out at night to feed on fungi.

The closely related great grey slug (*Limax maximus*) is far more tolerant of human presence and, as well as living in woods, can even be found in gardens. It is also less selective in its diet and, in addition to fungi, feeds on decaying plants, and very rarely on living ones.

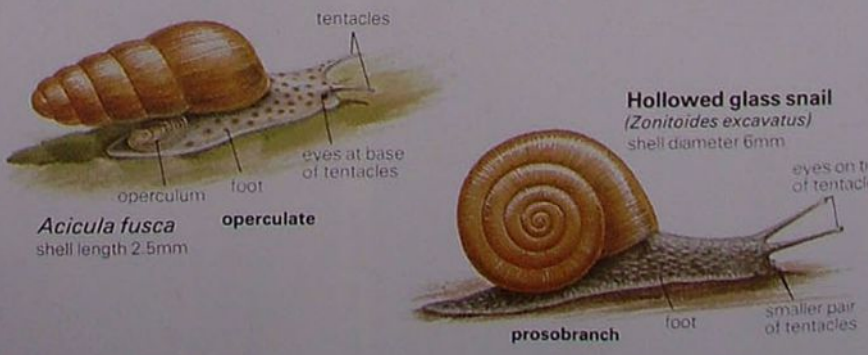
As with the majority of land snails, the great grey slug is hermaphroditic, each slug possessing both male and female reproductive organs, and so any other slug of the same species is a potential mate. In courtship, the two slugs circle and caress each other with their tentacles for up to an hour and a half. They then proceed to mate in a truly remarkable way–suspended in mid-air on a rope of mucus.

Woodland snails Several snails are known as glass snails because of their semi-transparent glossy shells. They are often carnivorous and have sharp teeth with which they grasp worms in burrows and slowly withdraw them until they are helpless on the ground. Some may bore holes through the shells of other snails, including other glass snails, and feed on the soft contents. One such species is confined almost exclusively to woodlands. This is the hollowed glass snail (*Zonitoides excavatus*), so-called because of the depression under its shell. It is widespread in small colonies throughout much of Britain, yet is hardly known elsewhere in the world.

The hollowed glass snail is one of the few snails never found in lime-rich soils; indeed it is rare to find any other snail or slug in the same area as it, and this gives a clue to its choice of habitat: it seems that it is not the lime-rich soil that the hollowed glass snail dislikes, but the competition from the numerous snails of other species that live there. This species breeds in the spring, mating involving the use of what is known as 'love darts'. These are small spears (slightly twisted in this case) which are forced into the partner's body. The use of such love darts is widespread among different types of snails, though their purpose is not understood.

The plaited door snail (*Cochlodina laminata*) has an elongated club-shaped shell and,

Operculate versus pulmonate



as with other door snails, derives its name from the plate or door that closes over the opening to the shell when the snail is inside. The shell opening also has a series of folds (sometimes called teeth) which hinder any predatory beetle trying to get inside. This species favours ashwoods and beechwoods.

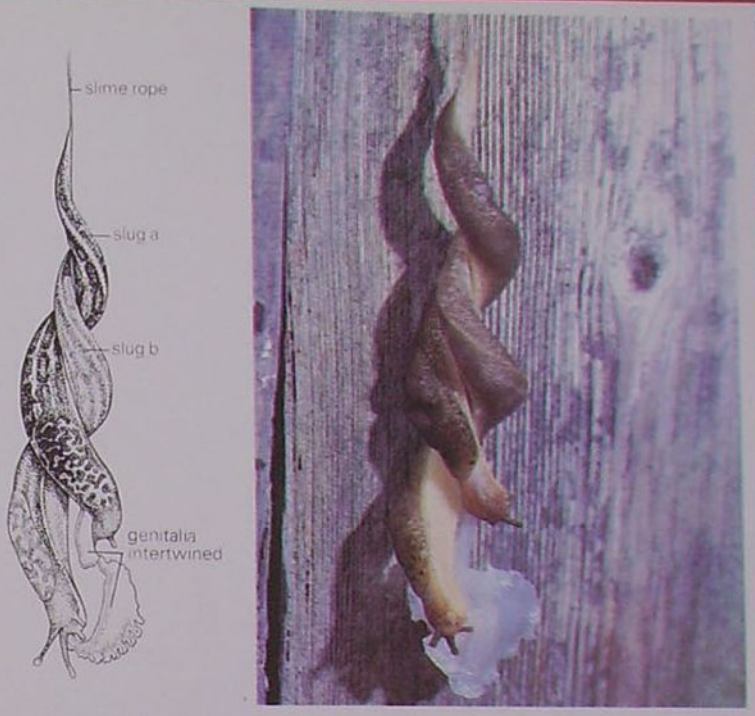
Operculate snails The snails mentioned so far are known as pulmonate snails because they breathe with lungs. All but two of our land snails belong to this group, the two that do not belonging to another group known as operculate or prosobranch snails. The latter group are more closely related to sea-shore winkles than to other land snails.

One of our two operculate snails is *Acicula fusca*, an extremely tiny snail with a cylindrical shell a mere 2mm long. Needless to say, it is extremely difficult to find, even when you are looking in its favourite habitat of old beechwoods. In operculates the sexes are separate and the eyes are not set at the tips of the long thin tentacles–as they are on pulmonate snails–but are borne on little stumps at the base.

The name 'operculate' comes from the presence of a disc called the operculum on top of the snail's tail. It can be clearly seen when the snail is crawling and once the animal withdraws into its shell the operculum forms an effective barrier to predatory insects. It may also prevent the snail from drying out.

Our other operculate snail is *Pomatias elegans*, a larger species with a robust shell growing to more than 15mm long. It is now restricted to lime-rich soils but the existence of numerous fossils of this species shows that it was once much more widely distributed. Some people believe that this is because the climate was warmer thousands of years ago, while others suggest that the quality of the soil has changed during that time.

During this century *Pomatias elegans* has disappeared from many sites, and all attempts that have been made to introduce it into what seems to be an ideal area have failed. Nevertheless, in most places where this species is found it is present in large numbers, and it seems to be in no immediate danger of dying out in this country.

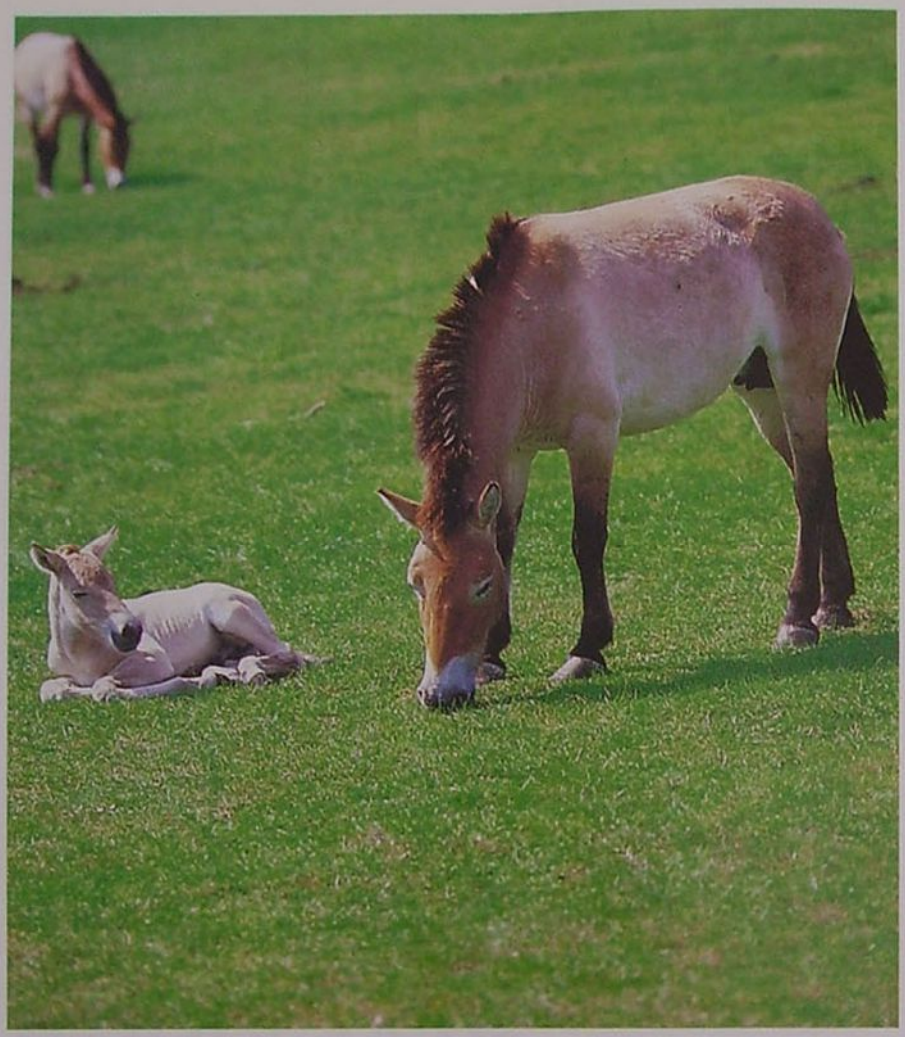


The rope trick of the great grey slug

Mating between two great grey slugs takes place on the end of a rope of slime. The two slugs climb up to an elevated point (in a wood, usually the branch of a tree) and then drop down suspended from a mucus thread. They remain locked together in a mid-air gyration while sperm is exchanged between them. They then separate, the first slug usually by climbing up the thread, while the second either eats its way back up the thread or drops to the ground.

Right: A young specimen of a giant black slug on a frond of wood horsetail. It would not be browsing on this plant, however, for it has a very selective diet consisting solely of fungi.

Below: Two plaited door snails mating. This species is usually found among ash or beech (in beechwoods it can easily be mistaken for a fallen beech bud). It spends the day hidden among fallen leaves, moss and roots, at night climbing a tree trunk to feed on lichen.



Above: The present Asiatic wild horse, or Przevalsky horse, was one of the ancestors of many of the pony breeds of Europe, including today's British native ponies.

EVOLUTION OF HORSES

The modern horse has evolved over 70 million years. Fossil finds in the Mendips suggest that today's Exmoor pony is a direct descendant of these ancestral animals.

That modern horses are related to zebras, asses, and even to tapirs is easy enough to accept; it does, however, at first sight seem unlikely that the long-legged, speedy, graceful animal that is the modern horse could in any way be related to the heavy, short-legged, cumbersome rhinoceros. Yet all these animals belong to the order Perissodactyla, which is characterised by, among other features, hoofed feet on which there is usually an odd number of toes and in which the axis of the foot passes through the middle toe.

But the evolutionary relationship with the rhinoceros is not the only remarkable feature in the story of the development of the horse. Perhaps even more astonishing is that from the Eocene epoch (60-70 million years ago) there is a comprehensive fossil record of the evolution of the horse from a small animal about the size of a fox to a pony-sized animal that lived between one and two million years ago, and from which present day horses have developed. (In case this appears an over-simplification, it should be mentioned that other fossils have been found that for various reasons do not fit into the almost direct line described above; some of them developed into separate lines of horse-like animals which then became extinct.)

The primitive horse The small Eocene creature, now recognised as the primitive horse, is known as *Hyracotherium*, or, more popularly, *Eohippus*. Although small, it was recognisably horse-like in appearance–lightly-built, with long, slender legs clearly designed for speed, and a long, low skull. Two of *Hyracotherium's* most interesting features from the evolutionary viewpoint were its limbs and teeth. The former showed significant variations from the primitive limb of land mammals, the pentadactyl, which, as the name suggests, had five digits. In *Hyracotherium* the 'ankles' and 'wrists' were raised so that the animal walked on the tips of the digits. The hind limbs had three digits (plus one vestigial) and the front four, only three of which were functional. Each digit terminated in a small hoof.

The 44 teeth gave some indication of the feeding habits of this primitive horse. They were generally low-crowned with long roots, and the cheek teeth had conical cusps specialised to some degree for grinding, probably to deal with soft leaves in swampy forests. From the point of view of future development it is worth noticing that the pre-molar teeth were unmodified, except for the last two in the

Naming the parts of a horse

upper jaw which were triangular in shape. The pattern indicates a browsing rather than a grazing habit of feeding.

American studies It is popularly believed that horses evolved only in what is now North America. Here the evolutionary history of the horse has been studied extensively from an almost complete series of sedimentary deposits from the Eocene onwards in which the fossils of horses have been found. However, it is less well-known that *Hyracotherium* fossils have also been found in western Europe and in southern England, although the later stages in equine evolution are almost entirely unrepresented in the British Isles.

Thus it is to North America we must go to follow the evolutionary trends towards the modern horse. There, from the Eocene onwards, fossil remains show how the changes took place from *Hyracotherium* to an animal more nearly approaching, if not modern horses, at least modern ponies–the distinction being made on the grounds of size rather than on other anatomical variations.

Over those millions of years at least 11 changes occurred. They include an increase in size; the legs and feet became longer; there was a reduction in the number of toes, with the middle one surviving; the back straightened and became much less flexible; the incisor teeth became wider and some pre-molars developed into proper molars; the crowns of the teeth became more complicated, and those of the cheek teeth became higher; the front of the skull and lower jaw became deeper to accommodate the increasing height of the cheek teeth; and the brain increased in size and complexity. Most of these features are now seen in modern horses.

From *Hyracotherium* (*Eohippus*) the next stage, *Protohippus*, stood about 46cm (18in) high. It differed from its predecessor in the loss of the vestigial digit of the hind foot. Then in the Middle Eocene (50 million years ago) came *Orohippus* which had further increased in size and its pre-molar teeth had developed into true molars. Both trends continued in *Epihippus* of the late Eocene. At this stage a gap developed between the back and front teeth–in modern horses the space forms the 'bars' of the mouth where the bit part of the bridle lies.

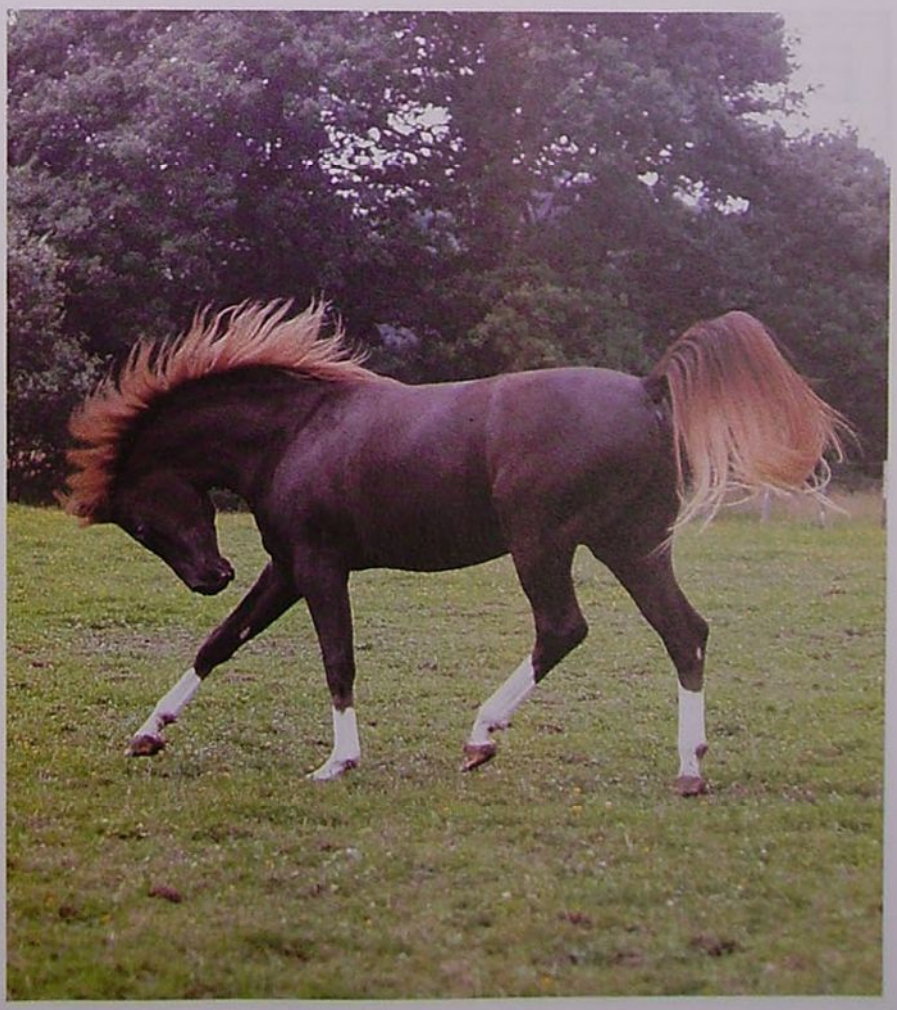
During the following Miocene and Oligocene, *Mesohippus* and *Miohippus* showed three toes on both hind and fore feet, with an extremely rudimentary vestige of the fourth digit remaining on the front. The legs were longer–in some cases even longer (relatively) than in modern horses, and the teeth suggested that the food the animal browsed was probably hard and dry. These animals were about 63cm (25in) high. A fascinating sideline on the story of the evolution of the horse is that during the foetal life of modern horses they go through a stage when they actually possess the three digits as in *Mesohippus*.

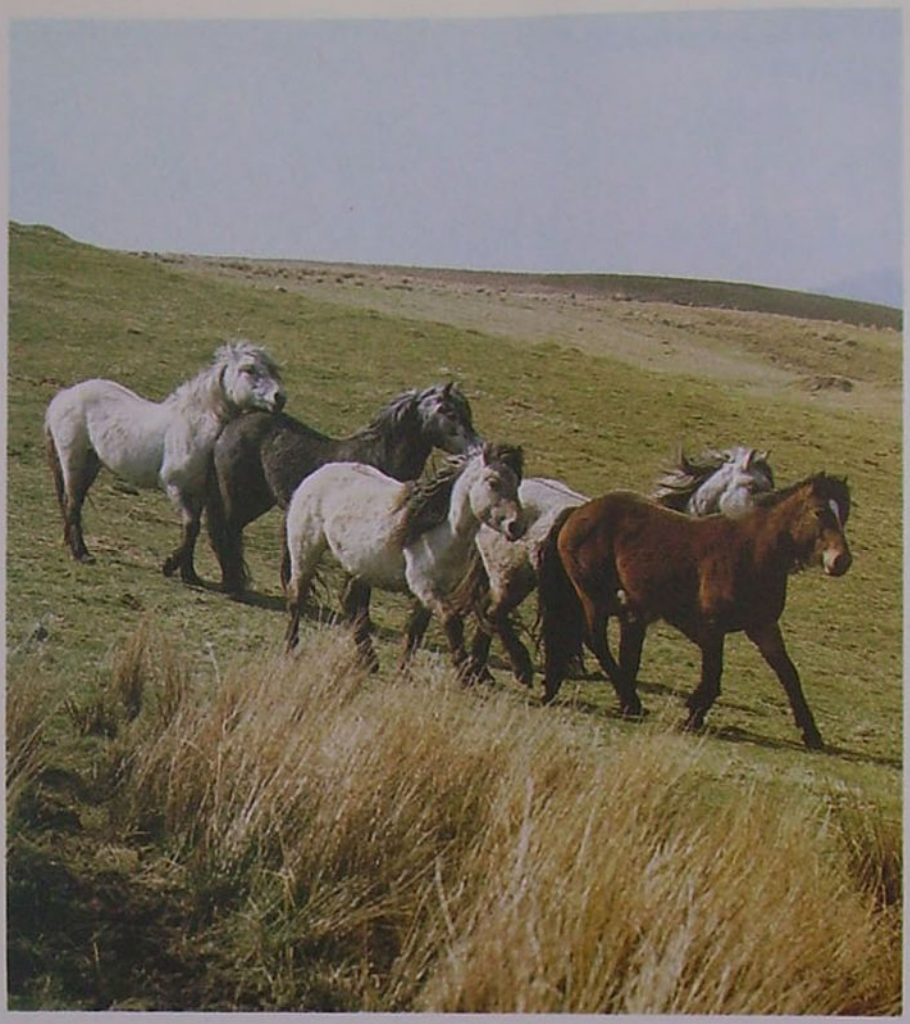
In the Upper Miocene the horse appears to have finally completed the change in dentition that suggests it had become a grazer rather than a browser. The teeth became longer and covered with cement. The animal, known as *Merychippus*, was about the size of today's Shetland pony, and although the feet still had three toes, the lateral ones had become greatly reduced; the horse walked on the middle toe which terminated in a rounded hoof.

From *Merychippus* two lines developed, one of which became extinct. The other–*Pliohippus*–eventually evolved into the more recent ancestors of the modern genus *Equus*. The extra digits were finally lost to external view, although remaining as vestiges under the

Above: Two to four million years ago some primitive horses of Northern America dispersed across land bridges throughout Eurasia. Those that finally settled in northern and central Europe found lush vegetation and developed into the Forest or Diluvial horse, a bulky, slow-moving animal that is the ancestor of today's heavy horses, such as this Shire (shown on the right in this picture).

Below: An Arab stallion–a highly evolved breed.





skin. Then, for reasons not fully understood, horses became extinct in North America. They were later re-introduced by the early European explorers.

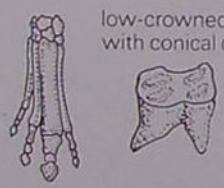
Migration Just how horses came to Europe and Asia is still debated. Some authorities suspect parallel (similar, but independent) evolution in Europe and Asia, and the presence of fossils such as that of *Hyracotherium* in Europe and in Britain is advanced to support the theory. However, it is more generally accepted that during the Pleistocene some of the primitive horses of North America migrated across land bridges to Asia, Europe and North Africa. Here they evolved along different lines, depending on climate and conditions. Some, including European horses, became bulky and slow moving; others, such as those from the Far East and North Africa, developed along lighter lines and became the ancestors of today's light riding ponies.

British horses Exactly when horses in their present form came to the British Isles is still discussed by experts. There are fossil remains of pony-type animals found in the Mendip caves dating back 10-60,000 years–too early for them to have been introduced by man but of course of very recent origin in geological terms. Researchers in the 1950s reported that the bones were of ponies which were part of a late migration from North America.

The greatest significance of these English bones is, perhaps, the manner in which they

Evolution of the horse

Fossil records show that the modern horse has developed over about 70 million years from a wild, dog-like browser to a highly evolved grazer.



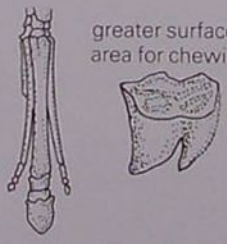
low-crowned teeth with conical cusps

4-toed, padded front foot, animal walked on tips

Hyracotherium (also known as Eohippus)

fox-like, a browser

EOCENE (about 70–60 million years ago)

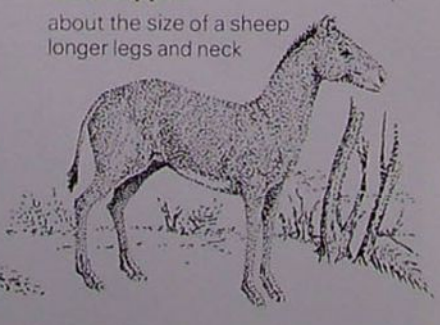


greater surface area for chewing

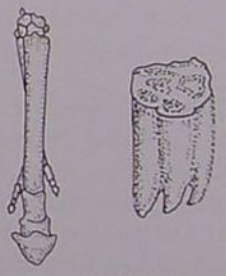
toes reduced from 4 to 3, with central toe enlarged, and harder pads

Mesohippus

about the size of a sheep
longer legs and neck



OLIGOCENE (about 35–25 million years ago)

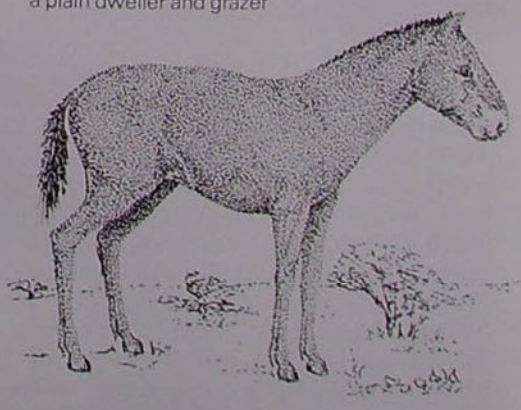


high crowned teeth covered with cement

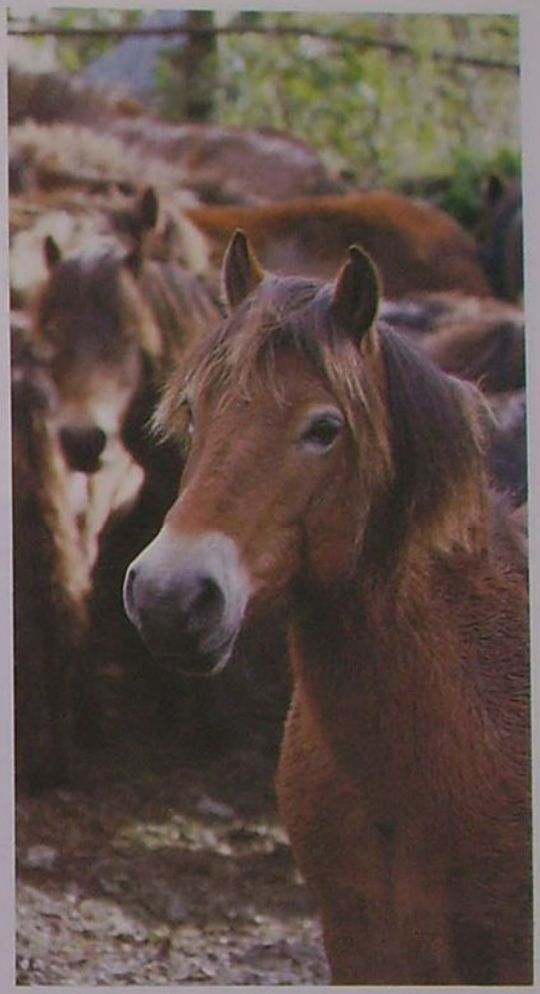
walked on central toe, hoof lost pad

Merychippus

pony-sized
a plain dweller and grazer



MIOCENE (25–10 million years ago)



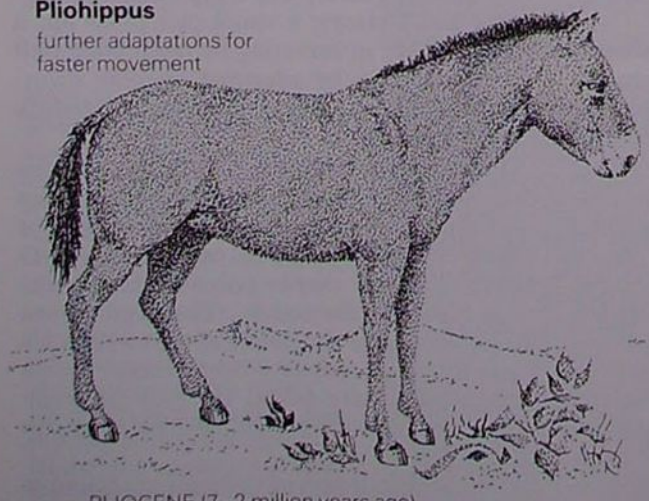
enable a link to be made between the primitive horse and present day British ponies. Comparisons of the Mendip and Alaskan fossils (dating from the Pleistocene) with the bones of modern Exmoor ponies suggest a striking likeness. Thus experts suggest that today's relatively isolated Exmoor pony is probably in direct line of evolutionary descent from the primitive horse and likely to be the only such animal now living here. (Other native ponies which might have been descended from similar stock have been more affected by man's selective breeding.) Certainly in terms of its skeletal structures the Exmoor is probably the truest direct, or almost direct, descendant.

Above and right: Exmoor ponies and, opposite page, Highland ponies. In the 1950s Professor and Mrs Speed of Edinburgh University worked in the Mendip caves on fossil remains of pony-type animals dating back 10,000-60,000 years. They compared these and Alaskan fossils with the bones of modern Exmoors, finding a striking likeness. They suggested that the modern Exmoor is probably in direct line of descent from the primitive horse.

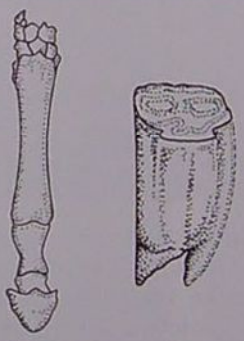
lateral toes disappeared from view
solid, single hoof

Pliohippus

further adaptations for faster movement

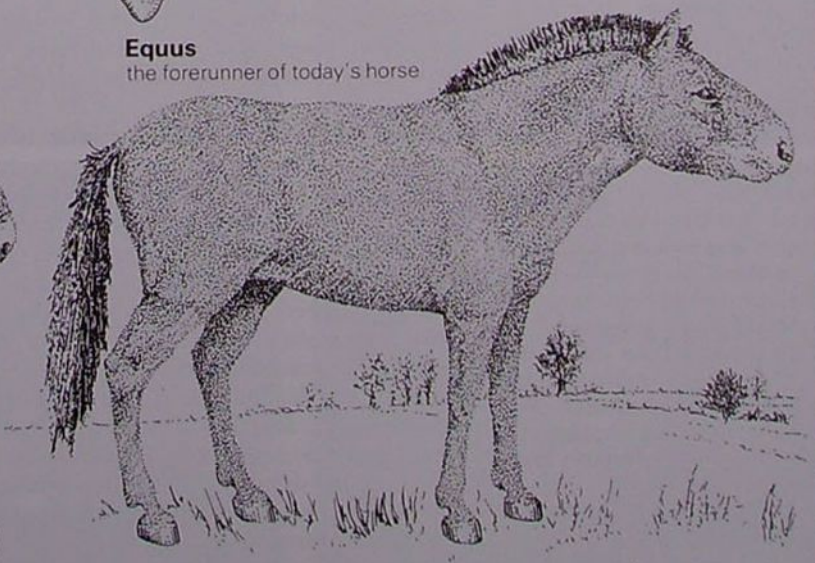


PLIOCENE (7–2 million years ago)



Equus

the forerunner of today's horse



PLEISTOCENE (2 million years ago–recent)

COLOUR FORMS AMONG INSECTS

Insects can vary in shape and colour within a single species–a phenomenon known as polymorphism. This may simply be a difference between male and female, but in the mottled grasshopper, for instance, there are twelve distinct colour forms.

Above: In a number of insect species the males differ from the females in appearance. Known as sexual dimorphism, this is especially noticeable in the speckled bush cricket. Females (right) of this species are equipped with strong ovipositors resembling curved daggers which they use to force apart plant stems and rotting wood, into which they lay their eggs. Since the males (left) do not perform this function they possess no such organs. Other instances of sexual dimorphism occur in dragonflies, the males of which have extra copulatory apparatus, and scorpion flies, whose males are characterised by a curved tip to their abdomen.

Many animals and plants show polymorphism in some way or another. In the context of insects, the term is used when different shapes or colours are found within an equivalent stage of the same species. Thus there are polymorphic larvae, pupae and adults.

Sexual differences Polymorphism is most familiar to us in the differences between the sexes of most insects. These polymorphisms exist for sound biological reasons: the differences between male and female insects (sexual dimorphism) have great survival value. The conflicting need to be visible to potential mates yet concealed from predators is a central problem to insects. In general terms, the male has to find, court and mate with a female, but the female has to remain relatively inconspicuous to protect her future offspring.

This sexual dimorphism is often seen in the colour of the sexes–as a rule the male is more brightly coloured than the female. The most familiar examples are among butterflies. Within the blue family, many species have brilliant blue males and obscure brown females. The purpose of these differences lies in the need for females to recognise males in courtship and for one male to recognise another. With females, their dull colour enables them to escape the attentions of insectivorous birds.

Males can also be distinguished from females by structures associated with mating: male dragonflies have an unusual accessory copulatory apparatus under the second segment of the abdomen, from which sperm is passed into the female, and male water beetles possess large pads on their forelegs which help them grip the female while mating. For females the biological function of producing and laying eggs means that they are often endowed with extremely conspicuous ovipositors.

Larval polymorphism Colour polymorphisms, as distinct from sexual differences, may be found in almost any stage of an insect's life. Insect larvae can be considered to show two phases of colour polymorphism: the first is differences between larvae of the same instar and the second is when instars differ in shape and colour.

In most insects the larval stages are remarkably uniform in appearance within any given instar. This is to be expected as these larvae are highly adapted to one way of life. The caterpillars of several species of moth are exceptions to the general rule and produce different colour forms. One example is the elephant hawkmoth, whose final instar caterpillars may be predominantly green or brown-grey. Similarly, third instar larvae of the emperor moth show an incredible range of patterns, all based upon black, green and orange. In this species it is difficult to find two caterpillars alike.

Colour polymorphisms are not restricted to within instars; many insects undergo dramatic changes in colour as larvae increase in size after each moult. Early instars of the swallowtail butterfly resemble bird droppings, but the later instars are a gaudy black and yellow. Such transformations occur because each change in the caterpillar's size requires a new protective strategy: a small caterpillar has a better chance of surviving by resembling bird droppings than by adopting warning colorations as it is not sufficiently large for the scare tactics to work.

Pupal polymorphism For most insect species the vulnerable pupal stage takes place hidden away inside a cocoon or buried in soil or wood. When a pupa is exposed, as with butterflies, there may be polymorphism in the colour of the chrysalids. The best known examples are the chrysalids of the swallowtail butterfly which may be either green or brown –green pupae are found on growing vegetation and brown ones on dead twigs or tree bark.

Similar colour polymorphisms are found in other butterflies such as the small white. Such differences in chrysalids are almost certainly

Caterpillars

Colour polymorphism in insects occurs among the larvae, pupae and adults. One of the most remarkable examples among larvae occurs in the alder moth caterpillar (see right). The early instars are perfectly camouflaged to resemble bird droppings, but the final instar takes on a gaudy black and yellow appearance which does little to conceal its presence; instead it warns birds of the caterpillar's distasteful properties.

related to camouflage and survival.

Adult polymorphism Colour polymorphisms in adult insects have attracted by far the greatest interest among entomologists. Some are clear cut forms determined by genetics, the classic case being that of the peppered moth with its three recognised colour forms. Other examples are found in the dark 'valesina' form of the silver-washed fritillary and the pale 'helice' form of the clouded yellow.

The value of adult polymorphism in the peppered moth is well known, but that behind the silver-washed fritillary and clouded yellow is less obvious. The valesina forms of the female silver-washed fritillary may be directly linked to temperatures as huge numbers of this normally rare variety were seen in 1976, a year of drought and high temperatures.

A remarkable adult polymorphism is found in the two-spot ladybird. The adult occurs in the well-known red with black spots version and also in a black with red spots form. This is thought to be an adaptation to help the ladybirds warm up quickly in early spring, the black individuals having a distinct advantage when basking–as black absorbs heat better than other colours.

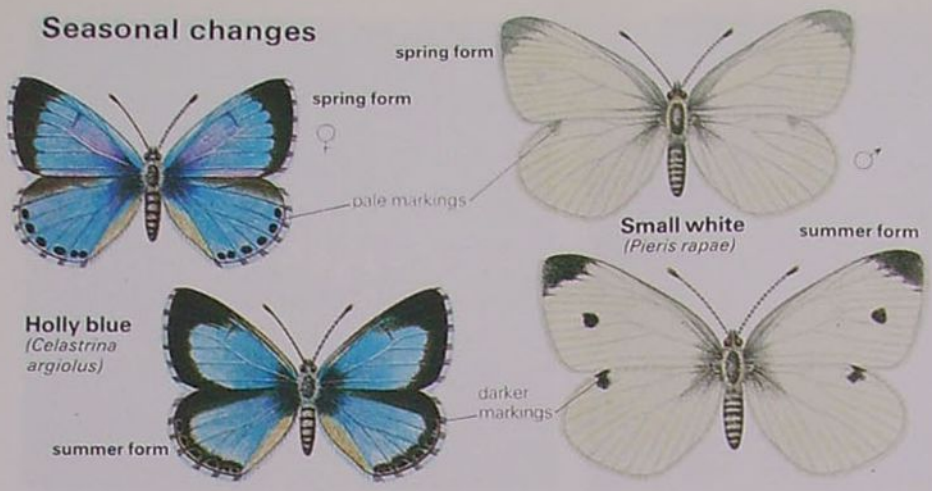
Multi-coloured bugs Among the bug order is a common insect called *Philaenus spumarius*, one of the spittle-bugs, whose larvae live inside the frothy blobs on grass stems. Adult

Chrysalids

Swallowtail chrysalids have two distinct colour forms: green chrysalids which are normally found on growing vegetation, and brown ones that occur on dead twigs or tree bark (see right). Research into how the caterpillars know where to pupate has revealed that, although they may be able to see the colour of their background, they take their cue mainly from the texture of the pupation site.

Adults

Differences between sexes are particularly apparent in some moths: the males are winged but the females are curious-looking wingless creatures. Most of the moths which exhibit this type of sexual dimorphism occur in the colder months of the year. Examples include the vapourer moth (see right), the pale brindled beauty, the mottled umber, the dotted border, the spring usher and the March moth.



Above: Seasonal variations in butterfly appearance are well known in the tropics but they also occur among a few British species. In the holly blue, females which are found in spring have less black on their wings than the summer individuals. Likewise with the small white, spring males have paler markings than their summer offspring. These variations are thought to be a result of the different temperature conditions under which the larvae and chrysalids develop.

Philaenus have a very wide range of colour varieties, from entirely black to pale brown. So great is the variation that rarely do two adults look alike. At least 24 different patterns have been recognised. The reasons why such variation exists in the same species are not clear, but an interesting feature of this polymorphism is that the different patterns exist at set frequencies in populations.

A common polymorphism in some groups of insects is the degree of wing development. Greenfly are a well-known example, with both winged and wingless forms. The food quality determines whether the greenfly are present as winged or wingless forms, an obvious adaptation to environmental conditions. Winged adults are about in late summer and autumn and reproduce sexually, but wingless females (which produce young parthenogenetically) appear in early summer or spring when food quality is good and they do not need to fly from plant to plant.

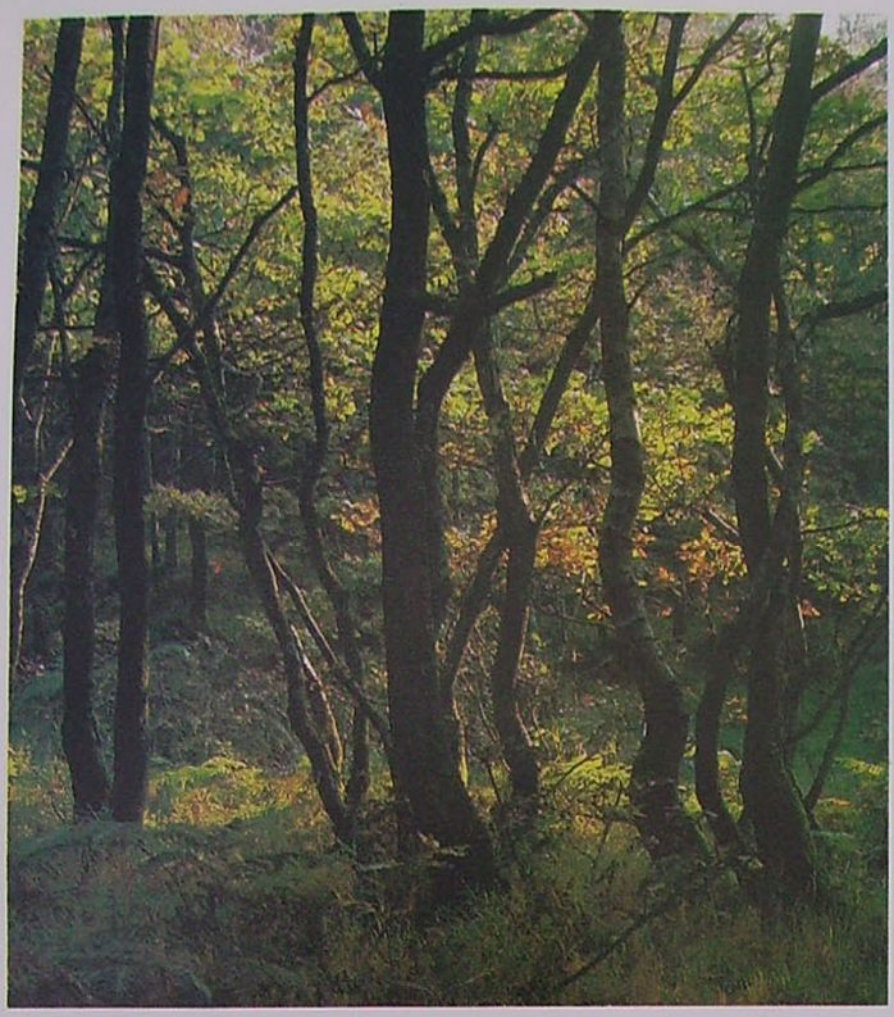
Extremes of polymorphism The need to adapt to different environmental conditions and food availability has been taken to extremes in the parasitic Hymenoptera. Gall wasps, particularly those which attack oak, usually have two parts to their life-cycle. In *Neuroterus quercus-baccarum*, a type of wasp which causes spangle galls on oak leaves, the overwintering grubs inside the spangle gall produce a generation of females. These lay their eggs in oak catkins which, when they develop into larvae, give rise to currant galls. The grubs inside these currant galls emerge as a sexual generation, with male and female adults, whose larvae give rise to spangle galls, thus completing the cycle.

The form of polymorphism evolved by the social Hymenoptera (bees, wasps and ants) is the most remarkable of all, though. Queen, workers and drones of the same species all perform different functions within the colony and consquently vary structurally.

Within the natural world there is an infinite variety of strategies for survival. Polymorphism is simply a piece of the jigsaw enabling insects to continue to reproduce and thrive.

Right: Grasshoppers are highly polymorphic as adults. The common field grasshopper (shown here) has at least twelve recognisable colour forms, the mottled grasshopper also twelve forms and the meadow grasshopper six. The colour form of a grasshopper reflects its surrounding environment, so that each variety is well camouflaged. Hence a common field grasshopper found on stony ground is likely to be greyish in colour.

Right: Even dragonflies display different colour forms within a single species. Among banded agrions the females are a greenish-yellow colour with slightly smoky wings and the males are a greenish-blue colour with dark blue bands on their forewings. These bands are particularly conspicuous when the male is in flight, and are important for territorial reasons, warning other males away from his territory and partner.



ECOLOGY OF OUR NATIVE OAKWOODS

Little remains of the natural broad-leaved forest which once stretched across Britain. Among that which survives there are birchwoods, ashwoods and beechwoods, but they are greatly outnumbered by woods in which oak is the dominant tree.

While the north of Scotland with its relict pine forests shows affinities with the Continent's coniferous region, much of the British Isles lies within a zone of natural broad-leaved forest which used to stretch across Europe south of the conifer zone. This broad-leaved forest was dominated by oak and, although it included other kinds of trees, it can reasonably be referred to as oak forest. If man had not been clearing away this oak forest for thousands of years Britain would still be largely covered by it.

Britain has two native species of oak–sessile and pedunculate. Both are widespread though the former tends to be commoner in uplands and the latter in lowlands.

Above: A sessile oakwood in Somerset. This type of oakwood is commonest in upland Britain–in south-west England, Wales, the Lake District and Scotland.

Right: Jays rely on acorns for their winter diet; a failure of the acorn crop can cause large numbers of these birds to flock from one wooded district to another in search of food. This was especially evident in the autumn of 1983 when acorns were destroyed by a gall wasp.

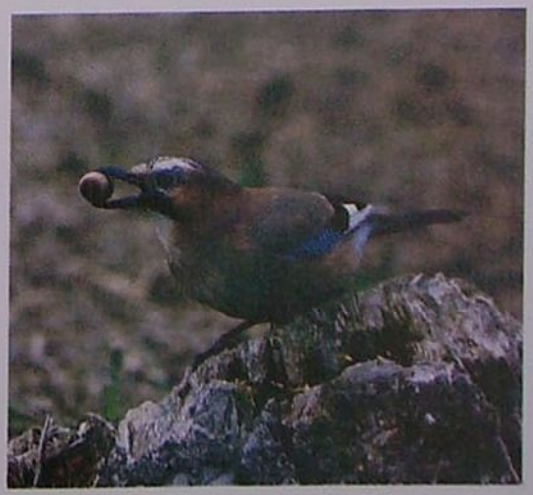
Upland sessile oakwoods Being primarily an upland tree, many hillside sessile oaks are very poor specimens, stunted by gales and infertile soils. Furthermore, man has been ill-treating them for centuries. Today many of these woods are neglected and livestock is allowed to graze in them, preventing natural regeneration.

In the typical oakwoods of highland Britain, with their lime-free soils, the oak's most frequent companion trees are calcifuges (plants which dislike lime) such as birch and rowan. The shrub layer, discouraged by grazing, is usually sparse or absent. In the most acid sites the field layer, if one exists, may be dominated by heather, bilberry or wavy hair-grass, with purple moor-grass or great woodrush in wetter places. But the chief botanical glory of these woodlands is the wealth of lichens, mosses, liverworts and ferns, especially where rocky gorges with streams and waterfalls cut through the wood.

On deeper soils sessile oakwoods often have great spreads of bracken. Conditions in steep woods are usually more fertile towards the bottom of the slopes because the soil's nutrients tend to accumulate here. A fair scattering of hawthorn, blackthorn, holly and hazel, and a good range of flowers such as lesser celandine, common dog violet, wood anemone, wood sorrel, bluebell and red campion all grow here. Fungi are also frequent in such woods.

Lowland pedunculate oakwoods In lowland Britain pedunculate oakwoods predominate, growing most typically on the fertile loams of the Midlands and southern England. Many of these woods exist on sites that have been under tree cover since the days of primaeval forest, although nearly all of them have been managed at some time by man. In some of the pedunculate oakwoods ash trees are so common that such woods may best be described as ash-oakwoods.

In the shrub layer there is usually a denser growth of hazel, hawthorn, blackthorn and holly than in the sessile woods of highland Britain. Guelder rose, elder, dogwood, common buckthorn and bramble are also characteristic.

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1 Purple hairstreak

2 Oak bush-cricket

3 Jay

4 Oak tortrix moth

5 Tree lungwort

6 Great spotted woodpecker

7 Stag beetle

8 Dog's mercury

9 Yellow archangel

10 Wood melick

11 Weasel

12 Dormouse

Left: A typical pedunculate oakwood with some of the wildlife you are most likely to find in it: High up in the **canopy** caterpillars of the purple hairstreak butterfly feed on oak leaves. The aptly named oak bush-cricket is also a common species in the tree tops and so is the jay which feasts on acorns in the autumn and winter months when food is scarce. Other caterpillars which feed on oak leaves are those of the oak tortrix moth–tiny creatures which roll themselves up in the leaves for camouflage. Flora and fauna associated with **tree trunks and branches** include tree lungwort, a lichen which thrives on the branches and trunks of old deciduous trees in damp locations, and the great spotted woodpecker which nests in old tree holes; stag beetles can be found excavating in dead oak wood. The **field layer** of a fertile pedunculate oakwood is where such plants as dog's mercury, yellow archangel and wood melick grow. Woodland mammals which have survived the destruction of our oak forests include the dormouse and the weasel.

Below: In oakwoods on steep slopes the soil in the lower half of the wood is usually fertile as the soil's nutrients are washed down from the higher land by drainage water. Here you can expect to find a good range of flowers including the attractive wood sorrel.

The field layer of pedunculate oakwoods is likely to include dog's mercury, primrose, sanicle, enchanter's nightshade, wood spotted orchid, early purple orchid, wood dog violet and, in damp places, ramsons. In the forest depths of long ago the tree trunks and boughs were probably covered with lichens and mosses. But in today's woodland patches, isolated among large fields, there is too much exposure to drying winds for many of these non-flowering plants to survive.

Nourishing the woodland In the bleak oakwoods of our uplands, with their lack of undergrowth, falling leaves tend to be blown away by the winds and have little chance of settling on the woodland floor to form leafmould. But in the shelter of fenced lowland woods (pedunculate oakwoods are normally fenced to keep out grazing animals) the autumn leaves gather with fallen trees, branches, twigs, and the bodies and by-products of animals, to form a deep litter which rots to produce a fertile topsoil. This leafmould teems with invertebrate life: microscopic creatures, but also springtails, mites, thrips, woodlice, centipedes, millipedes and various worms. Add to these several hundred species of ants, beetles and moth caterpillars and you begin to appreciate the army of activists busily breaking down the raw animal and vegetable matter.

The entire ecology of the forest and its inhabitants depend on this process, converting leafmould into a form of nourishment available to the roots of trees and other plants.

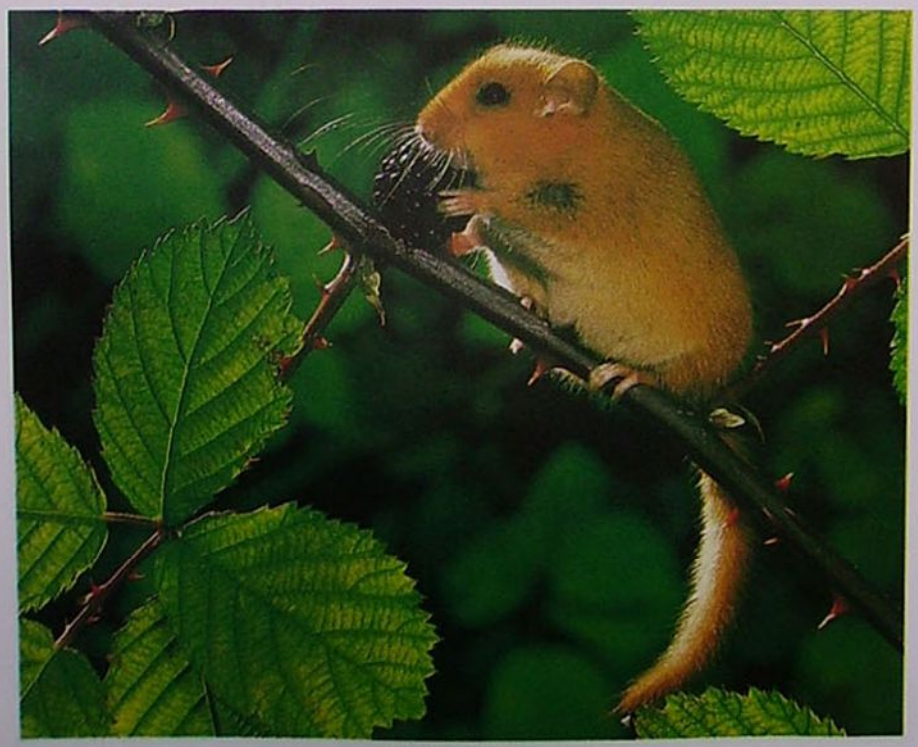
Insect life Oakwoods are well known for their large population of insects, an abundance that is most obvious in those years when moth caterpillars defoliate the trees in May and June. Yet although a great many moth species live on oak only a handful cause real damage: the winter moth, mottled umber, oak tortrix and a few others.

In any oakwood there is no missing the work of gall wasps. The wasps themselves are tiny but clues to their presence lie in the oak apples, marble galls, artichoke galls, currant galls and spangles which serve as both their food and their homes. Although most of these galls do no serious harm to the trees, in recent

Above: Surprisingly, only one of our butterflies—the purple hairstreak—has oak as its foodplant. This species is locally abundant in July and August when it spends the days fluttering above the tree-tops, sipping the sweet juices that aphids deposit on leaves. Other butterflies found in oakwoods include the speckled wood, green-veined white, holly blue, brimstone, comma, wood white, white admiral, the rare purple emperor and several fritillaries.

Left: Yellow archangel grows in the field layer of pedunculate oakwoods.

Below: A nocturnal mammal of oakwoods is the common dormouse.



years a particularly destructive gall wasp, *Andricus quercus-calicis*, has been attacking acorns in Britain.

Ravages of hunting The devastation of our native tree cover inevitably affected some of our larger woodland mammals. With their habitat rapidly diminishing they became more and more exposed to hunting and eventually the bear, beaver, wolf and wild boar were exterminated. Red deer and roe deer managed to survive very locally, and have since been allowed to increase in some districts. That badgers and foxes have survived so well is due to their gift for living unobtrusively and because they have adapted to modern times by lying up in woodland by day and foraging on farmland at night.

Also successfully surviving the destruction of our oakwoods are the stoat, the weasel and, in and near Wales, the polecat. Other common mammals in many oakwoods are hedgehogs, wood mice, bank voles, common shrews and pygmy shrews.

Acorn feast A great many birds use oakwoods either as all-the-year round habitats or for roosting, breeding and foraging. The bird population is at its maximum in spring and early summer when the woodland breeders are feeding their young on the great caterpillar harvest. Tits, warblers, starlings, chaffinches, redstarts and pied flycatchers are most prominent among these caterpillar eaters.

In autumn acorns are important in the diet of jays, rooks, wood pigeons and nuthatches. They are also eaten by carrion crows, ravens and great spotted woodpeckers.

While the ever-decreasing forests were losing some of their mammals, a few of the larger birds were likewise threatened with extinction. On the whole, though, birds are more mobile than mammals and so they are more able to relocate themselves. The raven, once widespread in British woods, has held on in the north and west. The buzzard, even more of an oakwood bird, has gone from much of southern and eastern England but remains abundant in the sessile oakwoods of highland Britain. The red kite has suffered most, however. Until less than two centuries ago it nested in woods throughout Britain but now this species is confined to a small area of Wales, breeding mainly in hillside oakwoods.

The future The area of oak cover in Britain is now minute compared with the forests of prehistory yet it is diminishing still further as woods are cleared to make way for conifers, farming land, housing and industry. Few new oakwoods are being planted to offset these losses so the surviving oakwoods become even more precious as wildlife habitats.

Especially to be cherished are the ancient woodlands, not only for their historical interest but also because they are of special ecological value. Often they are the last refuge of rare plants and animals that are particularly sensitive to interference and unable to colonize modern woodlands.

MAMMAL RHYTHMS

The lives of mammals are governed by natural cycles. All kinds of activities such as breeding, feeding, sleeping, grooming and hibernating depend on natural rhythms.

Above: Changes in day length act as an alarm bell to trigger many chemical and behavioural changes in British mammals. Here a grey squirrel sits in the branches observing its territory in midsummer when there is abundant food; but shortening days will soon signal the approach of winter and it will start to hoard food for the months of scarcity. For the red deer stag (below) decreasing daylength brings the animal into peak condition for the October rut.

Many people have heard of bio-rhythms, and some people even use them to predict when they will be at their peak or perhaps a bit under the weather–they can even be predicted by pocket calculators. These and many other rhythms form a complex mesh of activity governing not only the lives of humans but nearly every living organism as well.

Rhythm length Some rhythms last a short time. The heartbeat of the common shrew, for example, is a biological rhythm that repeats itself up to 500 times every single minute. Other rhythms span a full year. The breeding rhythms of most of our native mammals are variously orientated around the seasons: smaller mammals such as mice and voles tend to breed prolifically throughout the summer, yet no such activity features in their winter lives; the red deer battles and bellows to protect his harem for a few weeks in the autumn rut, but such behaviour never happens at any other time of the year.

A well-known rhythm, because it is important to humans, is the 24-hour day/night rhythm. Humans are diurnal–adapted to activity by day and to sleeping at night. Conversely the wood mouse is nocturnal, and with its large ears and protruding eyes is well adapted to an active existence by night, resting by day. Even this day/night rhythm is not as simple as may be thought. Other rhythms operate within the period. The wood mouse

feeds actively just after dusk to abate its hunger after the day's rest, and again just before dawn to stock up for the inactive day ahead. In fact the wood mouse needs about twice as much food as its stomach can hold each day, and this is probably the reason for the two peaks of feeding. This feeding rhythm is modified if the animal is starved, when it will range further afield for food, sometimes even in daylight. More normally, though, feeding rhythms are modified by the time of year. The feeding peaks of the wood mouse merge together during the short summer nights while other activities, such as grooming and suckling the young, occur below ground outside this dark period. This enables the mouse to make the best use of the dark period for such necessary above-ground activities as feeding and territorial behaviour.

Above: The yellow-necked mouse is mainly active at night, although within that time it has distinct patterns of behaviour.

Below: The mole lives almost permanently in darkness, well away from the hazards of surface life. It has three periods of activity during our 24-hour day. Each of these periods is followed by hours of rest, so it can be said to have three days to our one.

Activity is not constant during the day or night. The brown rat, for example, is normally nocturnal but is active in blocks of roughly four hours with periods of rest in between. The wood mouse is active for only two and a half hours at a time. Generally the active period is shorter in smaller mammals, and hence more frequent.

Some British mammals are not geared to a day/night cycle at all, although nocturnal behaviour is the norm for the majority of our mammal species. The activity of the common shrew is betrayed by its high-pitched squeak which can easily be heard by day or night. It is active in roughly two-hourly cycles during which it eats and sleeps. Field voles tend to be active by day and night, especially in summer, and with their smaller ears and eyes than the truly nocturnal wood mouse, are less specifically adapted to a particular part of the day/night cycle.

Moulting is another seasonal rhythm. The common pattern is shown by the stoat: the winter coat is moulted in spring to give a less dense summer coat followed by the reverse in autumn. The fox moults to lighten its coat in summer; the outer guard hairs are replaced immediately, but the thicker, warmth-giving underfur is not needed until winter and slowly builds up to its thickest in January when it is needed most. The rhythm of the shrew is complicated because the autumn moult starts above the tail and proceeds forward to the head and down to the underside; yet the spring moult is just the reverse, starting on top of the head and proceeding backwards and down.

When to do it? There are evidently many types of bio-rhythm going on all the time but how, for example, does the red deer stag know when it is October? How can the wood mouse tell from deep in its burrow when it is dark outside? Broadly speaking, there are two types of bio-rhythm: those that arise from within the animal–endogenous rhythms–and others that arise as a result of an outside cause such as a change in the environment–exogenous rhythms.

Endogenous rhythms can carry on with no environmental cue. The heartbeat is such a rhythm, and it is so independent that an isolated portion of cardiac muscle will continue beating. However, an endogenous rhythm is not totally beyond the influence of the environment and will in fact respond to it. For example, if an animal is startled, its heart rate will increase to carry more oxygen to the muscles which it will then use to escape from danger. Daylength, too, modifies endogenous rhythms: on a brightly moonlit night wood mice are much less active above ground than on an inky black night.

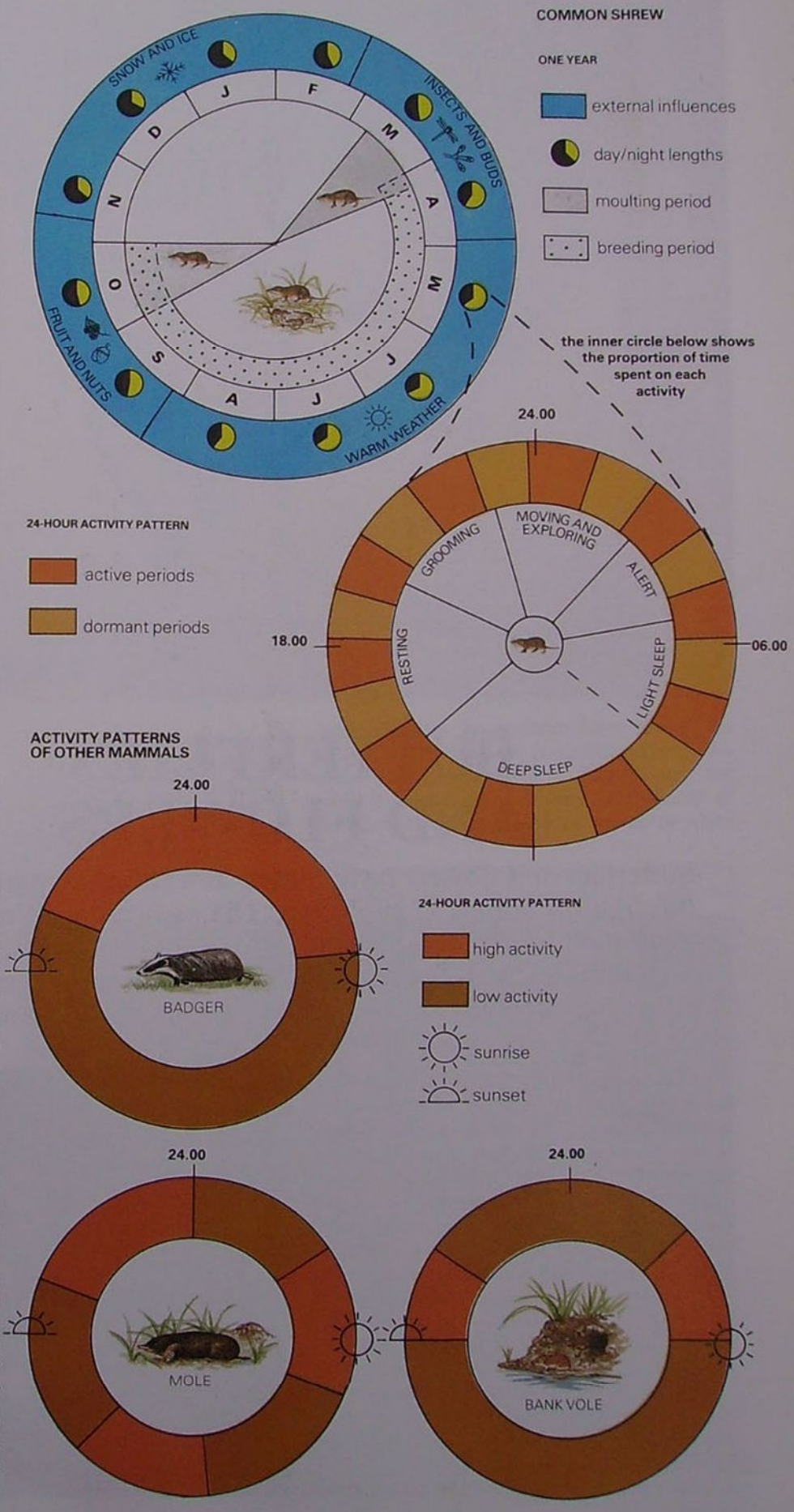
Exogenous rhythms are wholly dependent on external conditions. The breeding rhythm

of the wood mouse can be interrupted in the laboratory: if the simulated daylength is held constant as if it were winter with long nights and short days, the wood mice will not come into breeding condition. In the wild, however, shorter nights signal the arrival of the breeding season. But if temperature or food availability are low then the mice will not be ready to mate until later, in spite of the correct daylength. Moulting, too, is brought about by the change in daylength, but influenced by the temperature. Clearly, if the days are long enough but there is still snow on the ground, it makes sense for the animal to keep its winter coat a little longer.

The third 'eye' A third 'eye', present even in humans, is thought to play an important role in controlling some of the annual rhythms, such as breeding. In reptiles this eye is found just under the skull at the top of the head. Mammals retain only a glandular relic–the pineal body–with no lens or retina. Nevertheless, this pineal body can detect changes in daylength, so providing the vital link between conditions in the outside world and the body chemistry of the mammal. The pineal body is so sensitive that it is not even fooled by overcast skies bringing night along faster. The change in daylength acts as the long range weather forecast because increasing daylength signals better, warmer weather as summer approaches. Decreasing daylength signals the approach of winter. This single cue acts as an alarm bell to trigger many chemical and behavioural changes. Thus longer days stimulate hormonal changes in mice and voles to bring them into breeding condition, along with associated behavioural changes such as the establishment of territory and social hierarchy. For red deer it is exactly the opposite: decreasing daylength brings them into peak condition in October; it initiates food hoarding in the grey squirrel, hibernation in the dormouse, and the loss of breeding condition in other small rodents.

Why bio-rhythms? Why do mammals need rhythms at all? The answer is straightforward enough–survival. The shrew would certainly die of cold if it were not feeding often enough, as its tiny bulk cannot hold much heat. Mice are adapted to a nocturnal existence to help avoid detection. Bats are nocturnal to coincide with the activity of their food source: the abundant night-flying moths. A herd of deer are brought into breeding condition together to ensure that only the best stags are allowed to breed to produce the best offspring. Breeding in October ensures that the calves are born in June–well after winter but not too late to cash in on the abundant food of the summer months, so as to be well prepared for the following winter. The breeding rhythm of the grey seal saves the bull a great deal of trouble. The cows all haul up on the beach at the same time each year to give birth and suckle their pups. At the same time, they are courted and fertilised by the bulls.

Mammal clocks



BUTTERFLIES AND FLOWERS

Above: This marsh fritillary butterfly is feeding on nectar. While doing this, however, it has accidentally picked up a large quantity of pollen which it will deposit on the next flower it visits, thus effecting pollination.

Butterflies and flowers have forged an intriguing partnership through the course of evolution. The association is mutually beneficial, for flowers provide food in the form of nectar for butterflies, and the latter in return pollinate flowers by accidentally picking up and depositing pollen.

When flowering plants first began to appear about one hundred million years ago their leaves became modified to form petals. These petals were presumably the colour of leaves at first but they gradually adopted a range of different colours. Some of these colours attracted certain insects, and the petals acted as landing platforms for these visitors. Natural selection favoured these plants, and they slowly evolved so that their colours became closely tuned to the visual range of insects. At the same time the petals became modified to provide better landing platforms.

Butterfly mouthparts Likewise the structure of some insects evolved so they could take advantage of the valuable food supply offered by the flowers. Insects that commonly visit flowers for food (in the form of protein-rich

Below: Not all butterflies feed on flowers. This white admiral is feasting on a sticky secretion caused by a fungus on the grass head.

pollen or sugary solutions of nectar) include bees, wasps, flies, beetles, bugs, moths and butterflies. Butterflies are the most obvious visitors, their large, colourful wings making them easy to see. Most British butterflies visit flowers and feed by sucking up the flower's nectar, although some tap other food sources as well.

The mouthparts of butterflies are especially adapted for this task: the proboscis (tongue) consists of two halves, each an elongated and modified equivalent to the maxillae (assessory jaws) of other insects. These two halves are hooked together to form a groove along which the nectar is sucked. The pressure needed for sucking up nectar is provided by powerful muscles in the pharynx (throat). Most nectar is particularly thick and so the butterfly first dilutes it with saliva.

Proboscis length The majority of butterflies are only able to feed on certain flowers, the length of their proboscis being the determining factor, since it may not be sufficiently long to reach the nectar in some flowers. Most of the blue butterflies (Lycaenidae) have a short proboscis. The small blue, for instance, has a tiny proboscis of just 5mm in length so it can only feed on flowers with relatively short corollas, such as kidney vetch and bird's-foot trefoil. Likewise, the adonis blue and chalkhill blue are frequent visitors to marjoram, thyme and field scabious, all species with fairly open flowers and short corollas. Other butterflies with a short proboscis include the hairstreaks (also Lycaenidae) which feed on bramble flowers, known for their open nectaries where proboscis length is of no consequence.

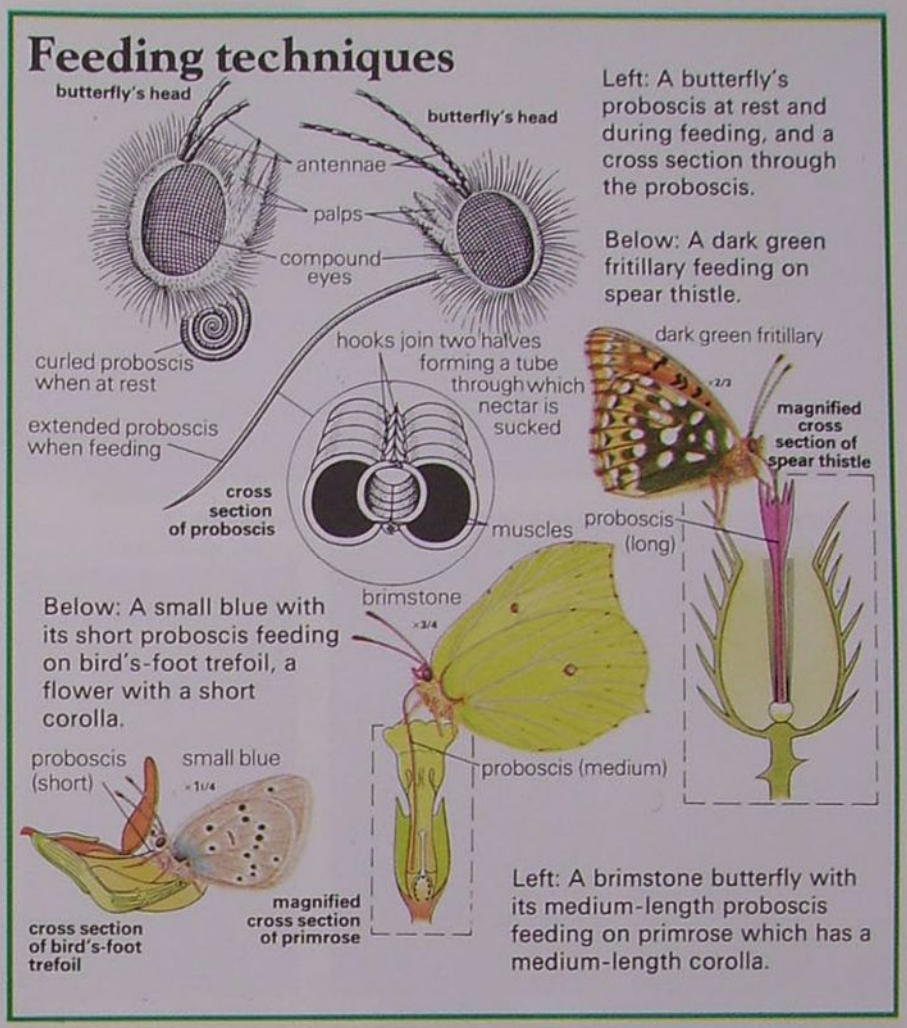
The whites (Pieridae) have a slightly longer proboscis, varying from 12mm to 17mm, which gives them a greater range of nectar sources. The common green-veined white, small white and large white visit both garden and wild flowers. Buddleia is a popular source of nectar, and in natural habitats plants such as bugle, bluebell, dandelion and ragwort are visited.

Considering their small size, the skipper butterflies (Hesperidae) have a fairly long proboscis, although relative to other butterflies they only come into the category of species with a medium-length proboscis. This permits them to feed from such flowers as viper's bugloss, tufted vetch, black knapweed and the hawkweeds.

Fritillary butterflies (Nymphalidae) include species with some of the longest probosces of any British butterfly. The dark green fritillary, equipped with a proboscis some 17mm long is a visitor to thistles, while woodland fritillaries, such as the silver-washed and high brown, are associated with scabious, spear thistle and bramble flowers.

The importance of colour So far we have seen that proboscis length can determine the range of flowers which certain butterfly species visit. But there are other important factors as well, flower colour being one of them. Several researchers have tested the colour preferences of butterflies using coloured papers and artificial flowers, and the general conclusions are that the majority of British butterflies prefer blue, yellow or white flowers.

The experiments showed that butterflies can distinguish between certain colours,



Below: The marbled white butterfly has a proboscis 10-16mm long and is especially fond of knapweed (shown here) and field scabious. The presence of these flowers implies that this butterfly may be near by.

Favoured flowers

LYCAENIDAE
HESPERIIDAE
SATYRIDAE
PIERIDAE
NYMPHALIDAE
MISC. SPECIES

A chart showing five different coloured flower species and the butterflies which they attract. Research has revealed that, on the whole, the majority of British butterflies prefer blue, yellow or white flowers. Hence ragged robin (below) appears to attract fewer butterfly species than the other flowers illustrated.

Bramble
(Rubus fruticosus)

Holly blue Brown hairstreak Black hairstreak
Chequered skipper Large skipper
Hedge brown Small heath Ringlet
High brown Silver-washed fritillary Heath fritillary Comma White admiral

Common thistle
(Cirsium arvense)

Common blue Chalkhill blue
Large white
Small skipper Essex skipper
Marbled white Hedge brown Meadow brown
Dark green fritillary High brown fritillary Red admiral Small tortoiseshell Peacock

Bugle
(Ajuga reptans)

Large white Green-veined white Orange tip Brimstone Wood white
Grizzled skipper Chequered skipper
Small pearl-bordered fritillary Pearl-bordered fritillary Heath fritillary Marsh fritillary
Duke of Burgundy

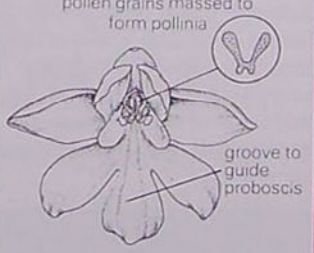
Common ragwort
(Senecio jacobaea)

Common blue Adonis blue Small copper White letter hairstreak
Small white Green-veined white Clouded yellow
Wall brown Scotch argus Hedge brown Meadow brown Small heath
Silver-washed fritillary Painted Lady Small tortoiseshell Peacock

Ragged robin
(Lychnis flos-cuculi)

Brown argus
Swallowtail
Large white Small white Green-veined white
Large skipper

Orchid pollination



Some orchids are specially adapted for pollination by butterflies, on which they rely almost totally. A special groove in the orchid guides the proboscis to where the pollen grains lie. The grains are massed together into pollinia which adhere to the butterfly's proboscis and are carried away to the next orchid.

Left: The wood white butterfly is commonly found feeding on bugle in woodland. This species and other whites have a moderately long proboscis varying from 12mm to 17mm.

although by no means all of them. The large white butterfly, for instance, distinguishes between three main colour groups–red/yellow, green/blue-green and blue/violet. That is to say it can tell the difference between red and blue but not red and yellow. Butterflies were also shown to have certain colour preferences: in nature the large white prefers purple, violet or white flowers and shows little interest in yellow flowers. The small tortoiseshell, however, favours yellow and purple blooms.

Scent as an attractant Many flowers have subtle scents, unnoticed by us, which act as the first guide to a butterfly hungry for nectar. Despite this long-range signal, research has revealed that butterflies rely far more on sight to find and choose flowers. In experiments carried out with flower-visiting butterflies, it was found that they are attracted to large-sized colour models rather than small-sized colour models, indicating that vision does play a more important part than scent.

Scent, however, appears to be of greater importance to butterfly species that feed on non-floral foods. Tree sap, honey-dew and rotting fruit, even if they are concealed, are all extremely attractive foods to such butterflies as the red admiral and purple emperor. A butterfly searching for such food can be seen to zigzag from side to side as it follows the scent trail–a different flight from that of butterflies which depend mainly on sight and colour, as they fly in straight lines towards the

target.

Is there a pattern? The pattern of flower visiting by butterflies may seem entirely random to the casual observer, but this is not always so. In some cases an individual butterfly may skip from one flower species to another but at other times a butterfly visits only one species of flower in a day. A male wood white, for example, can move along a woodland ride investigating every purple flower, but feeding only on bugle. The pearl-bordered fritillary may also be seen doing exactly this at the same time of year.

The reasons behind the differences in the pattern of flower visiting often lie in the flowering time of certain plants. Like many animals, once a rich source of food has been found that butterfly quickly learns to maximise its gain by visiting only that type of flower. Hence a butterfly's emergence should ideally coincide with the flowering time of a specific plant–meadow brown butterflies usually emerge just as the brambles are coming into flower. By following a particular butterfly species through its flight season a change can be seen in the species of flower which it visits. Early emergences of the gatekeeper or hedge brown feed on the last bramble blossom before turning to the flush of ragwort as soon as it is available.

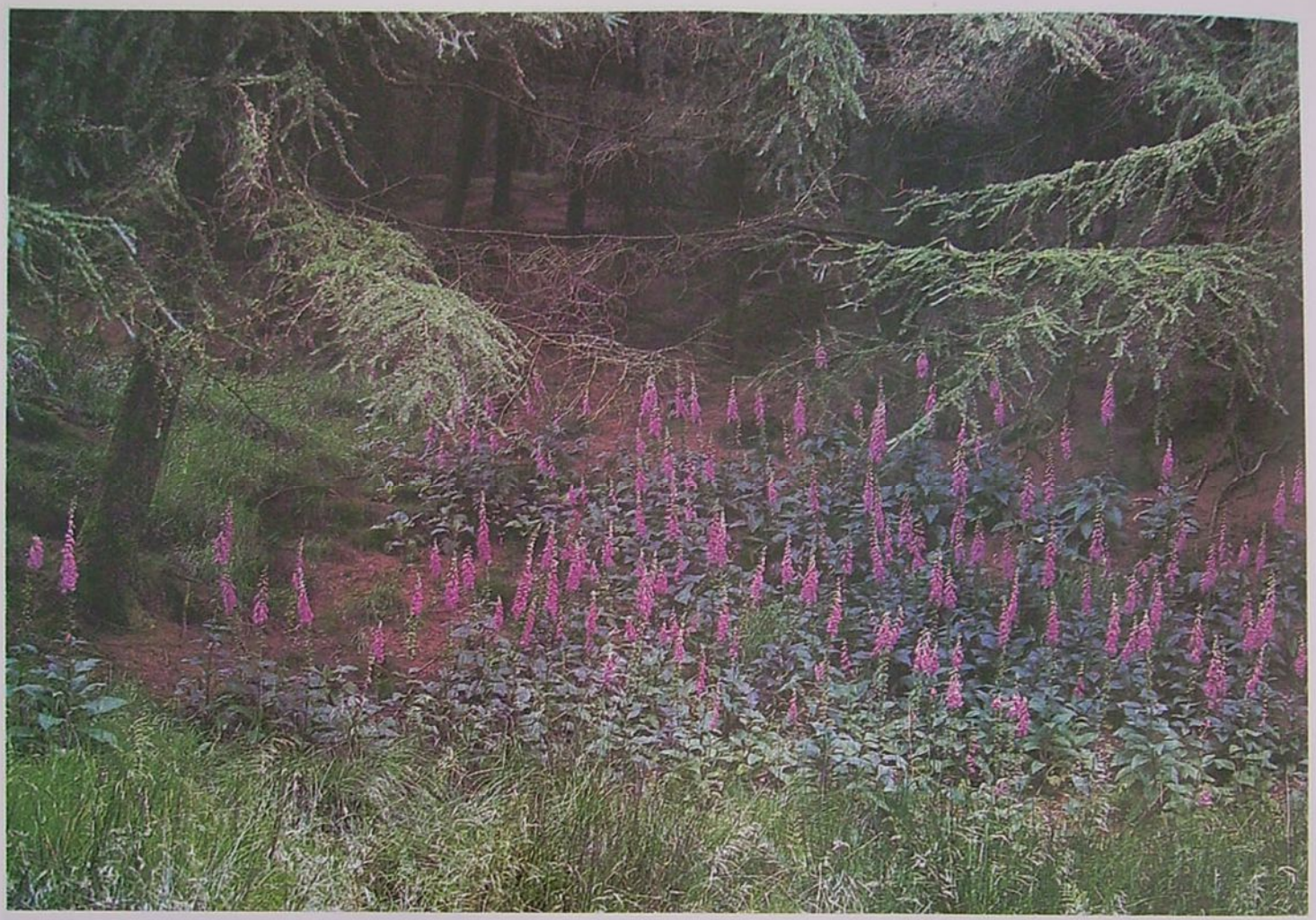
Feeding high or low The general availability of flowers and other foods also determines the number of butterflies which are seen. Take the hairstreaks, for instance. In seasons when the weather is dry aphids produce vast quantities of honey-dew on the upper leaves of blackthorn, ash and oak. This is a good source of food for hairstreaks and few venture down to the flowers. In a damp season, however, much of the honey-dew is washed off the leaves and butterflies are then forced to visit flowers for nectar. The overall effect is that numbers of butterflies may seem low in some dry years as they are all out of sight, flying high up in the bushes and trees.

Unanswered questions By no means all flowers are visited by butterflies. Some, like antirrhinum and foxglove, are specially adapted for bumble bee pollination and so you never see a butterfly feeding on them. Other flowers would appear to be suitable for butterfly feeding and pollination but they are also rarely visited–wild carrot, hairy willowherb and rosemary being such species. Are these flowers producing nectar at the wrong time of day or does the nectar have the wrong flavour, perhaps? Such unanswered questions confirm that we still know comparatively little about why certain flowers are chosen by butterflies. Much remains open to experimentation and observation on this subject, and can be attempted by anyone with sufficient patience to sit and observe butterflies feeding. Our knowledge of their feeding habits can be increased simply by noting the species of plant visited by an individual butterfly as it flits from one flower to another.

Above: Tree sap is particularly attractive as a food to many butterflies, especially nymphalids like the red admiral. A butterfly can detect the scent of tree sap from up to 30m (100ft) away.

Right: The orange tip, like other whites, has a moderately long proboscis.

Below: The small tortoiseshell is perhaps our most familiar flower-visiting butterfly, and has been recorded on almost every nectar-producing flower within reach of its 14mm long proboscis. Here several are seen visiting iceplant–a common garden species often called butterfly plant.



FLOWERS OF THE FIGWORT FAMILY

Figwort itself may not be the most attractive flower, but it gives its name to a vast family which includes such popular garden ornamentals as snapdragons, and familiar wild flowers like foxgloves, speedwells and toadflaxes.

What makes a plant a member of the figwort family (Scrophulariaceae)? As with most flowering plant families, the important characteristics are floral. The flowers have easily distinguishable sepals and petals, usually five of each, and they are joined at the base to form two structures known as the calyx (of sepals) and the corolla (of petals). The corolla is often in the shape of a tube–the petal-tube. In some family members, such as speedwells, the petals may appear separate but if you gently tug at one you will see that the petals are indeed joined at the base. Usually four or five stamens arise from inside the base of the petal-tube. Each flower has a single ovary which, after fertilisation, develops into a single capsule that opens to release the seeds.

The figwort family is fairly closely related to the nightshade family (Solanaceae) and is often confused with it. As far as native figwort species are concerned, the easiest distinguishing features are the petals and fruits: figworts have unequal petals, although sometimes they are scarcely so, while nightshades have equal petals; figworts have dry fruit capsules but most species in the nightshade family have fleshy berries.

These characteristics do not always apply to introduced species, so another way of telling the two families apart is to look at the buds: species in the figwort family have petals which are neatly wrapped around each other

Above: Foxgloves growing in a woodland glade. The foxglove (*Digitalis purpurea*) is one of the more familiar native members of the figwort family with its tall spires of purple-pink flowers.

Right: Black mullein (*Verbascum nigrum*) belongs to the mullein genus of the figwort family. Mulleins are characterised by the possession of five stamens and petals which are almost equal in size.

in bud, not longitudinally folded and crumpled as in the nightshade family.

Semi-parasitic plants The figwort family is also closely related to the parasitic broomrape family so it is not surprising that quite a large number of species in the figwort family are partially parasitic too. Although they attach themselves to grass roots and draw sustenance from them, they rarely cause much damage for their green leaves enable them to manufacture much of their own food from water, mineral salts and sunlight. These semi-parasitic species are usually treated as a separate group within the figwort family.

Two British genera in this group are the louseworts and the hay rattles. Like most partially parasitic species their petal-tube is rolled over on the edges and curved towards the tip to form a hood-like structure enclosing the stamens and stigma. The majority of semi-parasitic species have only four sepals instead of the more usual five.

The eyebrights–also semi-parasitic–have rather odd flowers as the upper part of the flower does not form the same sort of hood as in other semi-parasitic species: the lobes of the upper 'lip' are curled outwards to form an open-tubed flower similar to that of the non-parasitic species of the family. More than 20 species of eyebright occur in this country, and all have basically white flowers tinged with lilac, purple or yellow.

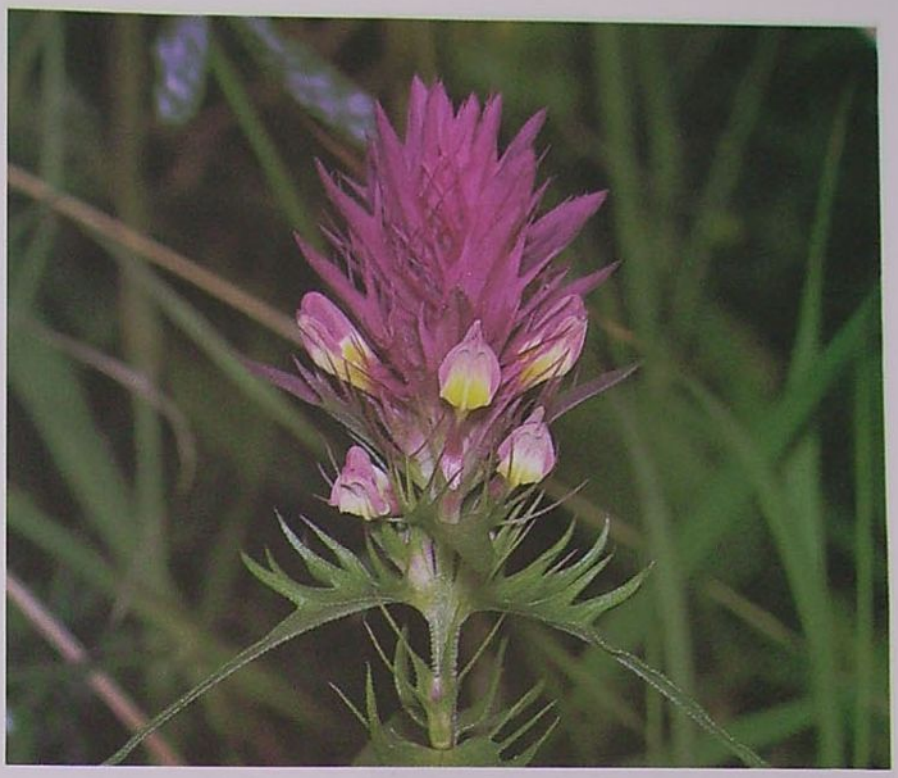
Bartsia is the common name given to another group of semi-parasitic species native to the British Isles. These plants can be distinguished by the size and colour of their flowers and the ornamentation of their seeds. Red bartsia, the most widespread of the species, has pink flowers and small, furrowed seeds. Yellow bartsia has larger yellow flowers and the seeds are small and smooth, and the flowers of alpine bartsia are dark purple and the seeds are large and prominently ridged.

Speedwells and foxgloves The speedwells are probably the most distinctive of the non-parasitic species in the figwort family. The tube at the base of speedwell petals is very short, and there are usually only four blue petals and two stamens.

Like other British members of the figwort family speedwells are normally herbaceous plants, although in rare cases they have stems that are slightly woody at the base. In other parts of the world, however, you can find members of the family that are woody–either shrubs or trees–and some of these have been introduced to Britain. *Hebe*, for example, is a species from the Southern Hemisphere which is widely naturalised in southern and western parts of the British Isles. Some species of *Hebe* in New Zealand reach tree-like proportions but the best known tree species of the figwort family is the introduced foxglove tree (*Paulownia tomentosa*). This is a beautiful plant with branched heads of purple flowers, shaped rather like those of foxglove.

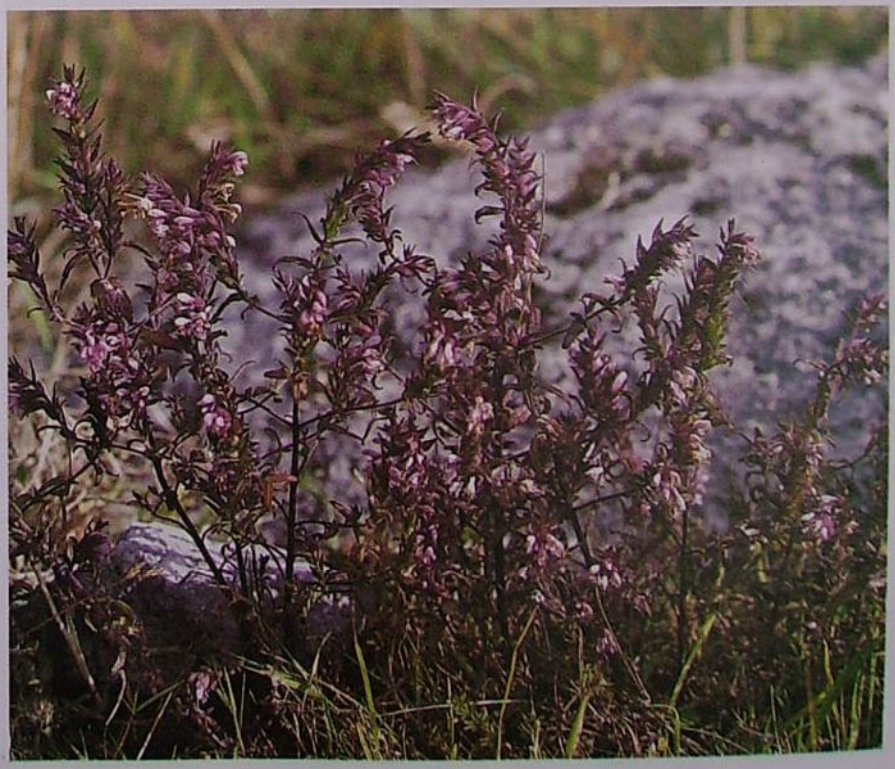
The foxglove genus, as well as including our familiar native foxglove, has a number of cultivated species which occasionally escape and become naturalised in the wild. Two yellow-flowered species, *Digitalis lutea* with small flowers and *D. grandiflora* with flowers about the same size as our native foxglove, are grown as garden plants. Another flower closely related to this group is Cornish moneywort, although it looks very different to the foxgloves with its creeping stems and kidney-shaped leaves.

Snapdragons and toadflaxes The snapdragon is one of the most familiar species in the figwort family owing to its popularity with gardeners. It is an introduced plant but has



Above: Field cow wheat (*Melampyrum arvense*) is a semi-parasitic plant found in corn fields. The cow wheats have only four sepals instead of five, and rather unusual flowers in which the petal-tube extends almost for the entire length of the flower.

Below: Red bartsia (*Odontites verna*) is another semi-parasitic member of the figwort family and was once used as a cure for toothache.



Left: The elongated heads of yellow flowers, each with a slender spur at the base of the petal-tube, make common toadflax (*Linaria vulgaris*) an easily identifiable species. This plant should never be permitted to grow in your garden for it spreads extremely rapidly, every centimetre of the roots producing a new plant.

Below: Heath speedwell (*Veronica officinalis*), or common speedwell as it is otherwise known, is a herbaceous species which grows on the dry soils of grassland, heathland and along woodland edges. It is a creeping plant which reaches a height of approximately 10-30cm (4-12in) and flowers between May and August. The open flowers with their projecting stamens enable small bees and flies to pollinate them. This species was believed to cure a large number of illnesses, including tuberculosis and leprosy.

become naturalised in many places. A similar species, common toadflax, which is native, is easily identified by its elongated heads of yellow flowers, each with a slender spur at the base of the petal-tube. A few other members of the family share the common name toadflax. These are ivy-leaved toadflax and small toadflax, both in different genera from that of common toadflax but with similar spurred flowers. The fluellens also have spurred flowers.

Flowers of the snapdragons and toadflaxes are outstanding examples of bee-pollinated flowers, with a physical barrier in the form of a palate which must be pushed aside to gain access to the nectar. The palate deters smaller insects which would otherwise steal the nectar without pollinating the flower in exchange.

Another distinctive group of the figwort family is the mullein genus which includes Aaron's rod. Mullein flower petals are almost equal in size and joined at their base to form a very short petal-tube similar to that found in the speedwells. Of the 250 species that occur worldwide, only five or six are native to this country although a handful of other species occasionally escape from cultivation. The flower colour is nearly always yellow.

Figworts and monkey-flowers The figwort genus itself consists of a number of species with relatively small, dull, reddish-brown flowers, found mostly in damp or shady places. In spite of their flowers being very different from those of the mulleins, the figworts have very similar seeds and capsules. Figwort flowers are pollinated by wasps; the short petal-tube into which a wasp can thrust its head, the colour and the late flowering date all being adaptations to this type of pollination.

Of the hundred or so monkey-flower species which are mostly native to North America, a handful have been introduced as garden plants to the British Isles. The two most common naturalised species, both yellow-flowered, are the monkey-flower and blood-drop emlets. A curious tale surrounds a third species, the musk. This is a sticky-leaved plant that was widely cultivated in Europe during the last century for its powerful scent. Around the turn of the century the plants inexplicably lost their characteristic smell. On turning back to wild plants for a fresh stock it was found that wild plants do not possess the scent and that the original cultivated material was probably all grown from a single abnormal scented plant.

The figwort family does not contain any important crop plants. There are a number of species which yield products used in various medicines, but by far the most important are the foxgloves from which the drug Digitalin is prepared and used for regulating heart activity in cardiac disorders. Most people, however, will continue to appreciate the figwort family for its aesthetic, rather than practical, value.

The figwort family

A guide to some of the more common members of the figwort family found in Britain.

1 Marsh lousewort (*Pedicularis palustris*).
2 Yellow rattle (*Rhinanthus minor*).
3 Common cow wheat (*Melampyrum pratense*).
4 Common eyebright (*Euphrasia nemorosa*).
5 Red bartsia (*Odontites verna*).
6 Yellow bartsia (*Parentucellia viscosa*).
7 Alpine bartsia (*Bartsia alpina*).
8 Brooklime (*Veronica beccabunga*).
9 Foxglove (*Digitalis purpurea*).
10 Cornish moneywort (*Sibthorpia europaea*).
11 Common toadflax (*Linaria vulgaris*).
12 Round-leaved fluellen (*Kickxia spuria*).
13 Ivy-leaved toadflax (*Cymbalaria muralis*).
14 Small toadflax (*Chaenorhinum minus*).
15 Great mullein (*Verbascum thapsus*).
16 Common figwort (*Scrophularia nodosa*).

WIGEON AND GADWALL

Wigeon and gadwall, like the goosander and red-breasted merganser, have colonized Britain since the start of the last century. While the gadwall dabbles for food in mallard fashion, the wigeon is unique, for it is our only grazing species of duck.

The wigeon is a medium-sized duck, intermediate in size between the teal and the mallard. It is rather shorter in the neck than other dabbling ducks, giving it a rounded, dumpy appearance. Wigeon often occur in large flocks, feeding together in dense packs, or wheeling in close formation flight.

The male wigeon is a handsome bird with a reddish-brown head and neck, emblazoned with an orange-yellow stripe running over the crown from the bill to the nape. The neck joins a pinkish-grey breast which merges into silvery-grey flanks and back. There is a conspicuous white patch at the rear of the flanks which contrasts with the black tail. The female is much duller, more or less brown all over, though with a certain reddish tinge. Both sexes have a short bill and steep forehead.

In flight, the male wigeon shows a prominent white forewing which is visible at considerable distances and quite unlike the wing pattern of any other duck. The female's wing lacks this white, though the dark speculum (wing panel) is bordered with white, particularly at the rear. Male wigeon have a distinctive whistling call, most often heard from flocks on the wing.

How many wigeon? The wigeon is a very numerous species; it has been estimated that up to a million birds winter in Europe and around the Mediterranean. Of these, some 200,000 winter in Britain but only a very small part of this total comes from our native breeders. There are thought to be no more than 500 breeding pairs in the whole country, the majority of them in Scotland and northern England. The breeding range of the species extends from Iceland and northern Britain across Scandinavia and right across the northern part of the Soviet Union.

Those breeding in Britain have their eggs in April in the south, and in late May and June in the north. They nest near freshwater lakes and streams, usually laying seven or eight eggs in a single clutch.

Wigeon only began to nest in Britain in the last century, the first pair being found in Sutherland in 1834. From there breeding spread south into England.

Traditionally a coastal species in winter, wigeon are now finding new winter sites. Once it was rare to see flocks of wigeon inland. Even by 1940, only small numbers were found regularly away from the coast. In the last 30 years, though, several quite large concentrations have built up at inland sites, where birds feed on short grass in wet fields. Chief among these sites has been the Ouse Washes, lying astride the Cambridgeshire/Norfolk border. Here there have been counts of over 30,000 birds. Many smaller flocks are now seen regularly, particularly at reservoirs and some gravel pits, where the banks are mown or grazed.

A unique duck The wigeon is the only

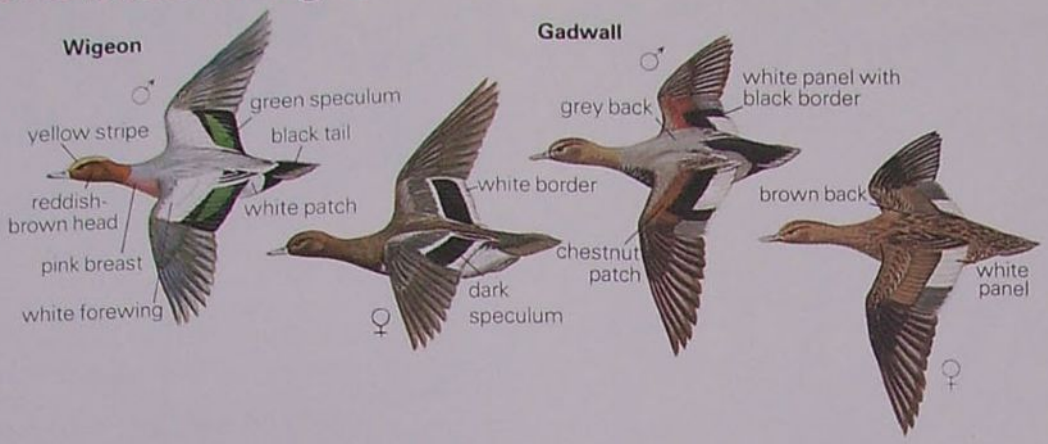
Above: A pair of gadwall, the male swimming ahead. Tussocks of rushes are the favourite nesting cover.

Gadwall (*Anas strepsera*). Dabbling duck. Resident, with annual influx of wintering birds. 50cm (20in).

Wigeon (*Anas penelope*). Grazing duck. Resident, with large annual influx of wintering birds. 46cm (18in).

Right: A wigeon duckling; its steep forehead resembles that of its parents.

The birds in flight



grazing duck in Britain, feeding almost all the time out of the water. On estuary mudflats it feeds on eelgrass (*Zostera*) and on such algae as *Enteromorpha*. On saltings and at inland sites the ducks graze on short grass and other vegetation. Because they cannot readily feed in long, rank growth, they nearly always feed on areas which have been initially grazed down by sheep or cattle.

Identifying the gadwall This is a smaller duck than the mallard but larger than the wigeon. The male lacks any particularly distinctive features, being overall grey, although darker on the back than underneath. The tail is black but there is no contrasting white patch just in front of it, and this is a useful identification feature because most other dabbling ducks, such as mallard, pintail and wigeon, possess this white patch. In flight, the gadwall is much easier to identify as there is a bold white area on the rear of the secondaries, contrasting with black and chestnut on the shoulder. The female gadwall is very like a female mallard but has a noticeably more pronounced forehead and a thinner bill. In flight, white on the speculum is the best identification guide.

Fewer than wigeon The gadwall is widely distributed in Europe, Asia and North America. It breeds in temperate latitudes, rarely getting as far north as many other of the dabbling ducks that breed in Europe. Most of the gadwall in north-west Europe, including those in Britain, stem from introductions. The first breeding record in Britain dates from about 1850, when a wing-clipped pair were released in Norfolk. From there they spread to other parts of Britain and to Northern Ireland, some of the spread being natural but also aided by further introductions.

The total number of breeding pairs in Britain is probably of the order of 500-700, and is still increasing. The peak number wintering is approaching 5000. British-breeding gadwall are either resident throughout the year or move south and west for the winter, particularly during cold weather.

A dabbling life-style Gadwall are found on fresh and brackish water, but mainly on the former where they feed in the shallows on seeds, insects and the softer parts of aquatic plants. They are rarely seen feeding on land. They feed by dabbling in the surface layers or by upending. Their breeding habitat includes small lakes, reservoirs, meres, slow-flowing rivers and freshwater marshland.

A pair of gadwall adopts a territory around the nest site and defends this against other gadwall pairs. This territory may be from 10ha to 30ha (24-72 acres) in area, and contains a number of favoured feeding sites, and also places where the birds can stand out on the bank to preen and sleep.

Raising young Initially both the male and the female use the whole of the territory, but when the female begins nest-building and then starts to lay the clutch of eggs, she may restrict herself to just those parts of the territory closest to the nest, using perhaps only one preferred feeding site. Once incubation has begun, she continues to use her preferred site when she leaves the nest for her twice-daily bathe and feed, but by then the male is losing interest in nesting and deserts the area.

Below: A flock of wigeon on a small island in a freshwater lake; some of them are grazing. The species has ceased to be a purely coastal one, moving inland to lakes and marshes during the present century.

ASHRIDGE IN THE CHILTERNS

Ashridge Park is an estate in the Chilterns with three quite separate habitats–woodland, downland and common land–each with its own assemblage of plant and animal species.

Opposite page: A misty morning under the beeches of Ashridge. The sparse undergrowth is a common feature of beechwoods, as the dense foliage prevents sunlight from reaching the ground for most of the summer.

Below: An edible dormouse among the autumn leaves of the sweet chestnut. The Chilterns are the stronghold of this charming dormouse, so-called because the Romans regarded it as a delicacy.

Lying only 40km (28 miles) north of London, Ashridge Park covers 16sq km (6sq miles), encompassing parts of Buckinghamshire, Bedfordshire and Hertfordshire. This extremely rich habitat for wildlife attracts thousands of weekend visitors from nearby large towns and cities.

When the 3rd and last Earl, Lord Brownlow, died in 1921 his will directed the trustees to dispose of the whole of the Estate to meet death duties. Immediately 4600ha (11,300 acres) were sold and in 1925 a fund was initiated for the purpose of acquiring Berkhamsted Common and as much of Ashridge Park and adjacent woods as possible.

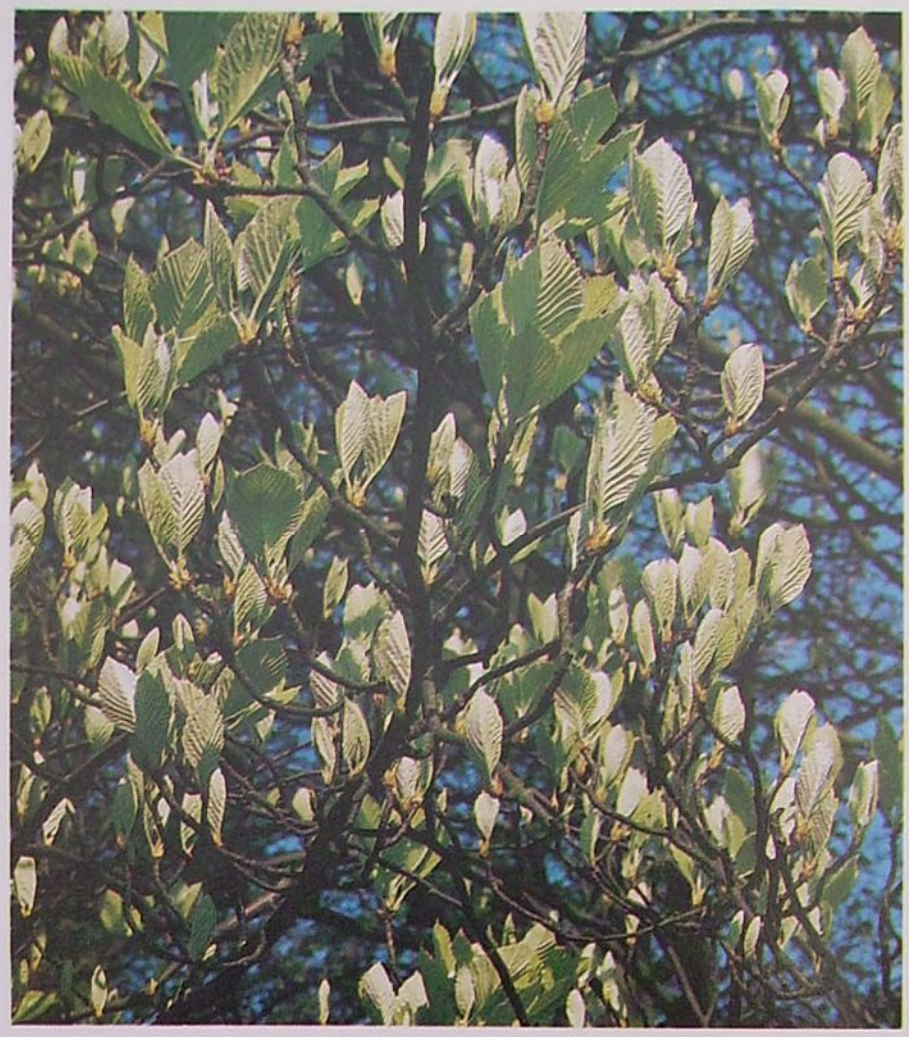
This fund eventually enabled more than 1200ha (3000 acres) to be bought by the early 1930s, and further land has since been bequeathed and purchased.

Wild woodland Some of the woodland at Ashridge dates back well over a thousand years, and it was once part of the vast Saxon forest between the manors of Berkhamsted and Little Guddesden. The two notable ancient woodlands surviving today are Frithsden Copse and Old Copse. These woods still contain most of their native flora and fauna, including magnificent oaks and beeches, the occasional hornbeam and, in spring, drifts of bluebells. The purple helleborine, though localised, is still a fairly common flower.

Among mammals associated with these woodlands perhaps the best known are fallow deer, which are totally wild and have descended from the deer of the original Park. In 1921 the Park contained approximately 150 red deer, 550 fallow and 25 sika. By 1945 one red deer remained, the sika deer had become extinct and the fallow was holding its own. Today, there are no sika or red deer, but there are more than 300 fallow deer and the muntjac or barking deer are also fairly common, though their numbers fall dramatically in severe winters. As well as the common dormouse, the introduced edible dormouse is also present in small numbers, this area of the Chilterns being its main stronghold.

Beech and bracken The huge commonlands which once covered much of the area are now hardly distinguishable from the woodlands. Remnants remain, however, due mainly to walkers and picnic parties, whose activities prevent the trees from encroaching. Silver birch, hawthorn, gorse, heather and bracken were quick to colonize these areas, making for a time an ideal habitat for birds such as stonechat and nightjar, neither of which are found there now. Nevertheless, interesting birds like the woodcock and redstart are still present, as is the hawfinch, particularly where there is a predominance of wild cherry and hornbeam.

A welcome sight is the lesser spotted woodpecker, which is far commoner than



most people think. This elusive bird, about the size of a great tit, is often overlooked in the high tree canopies where it spends much of its time.

One of the most attractive features of Ashridge is its beech hangers. These are small stands of mature beeches growing on the steep slopes of chalk downland. They extend along the slopes of the plateau from the village of Aldbury and finally peter out as the clay with flints gives way to the pure chalk downland of Ivinghoe Beacon. Beech woodland has no shrub layer and supports little vegetation, with the result that some of the plants you would expect to find in, say, oakwoods are absent here. However, these woods have their specialities such as sanicle, woodruff, white helleborine, fly orchid, bird's-nest orchid and in a few places spurge laurel. On the lower slopes of the hangers one can often find the whitebeam, perhaps the most beautiful of all the trees of the Estate.

Chalk downland The last and most spectacular habitat of Ashridge is the chalk downland. The best examples can be seen at Ivinghoe Beacon, Incombe Hole and Steps Hill. These areas had been grazed by sheep since time immemorial and as long as this continued the downland's shallow soil supported a close turf of fescue grass with a colourful associated flora.

Grazing ceased in the 1920s and 1930s when sheep became unprofitable. As a result the fescue turf deteriorated, giving way to coarse grasses, principally upright brome, while hawthorn scrub also began to encroach. For a time rabbits held the delicate balance in check, but with the outbreak of myxomatosis in 1953 the hawthorn began to invade in earnest. (It is difficult to imagine that at one time the hawthorn was a rare plant in the British countryside until extensively used as a hedging plant at the time of enclosures.)

The change from downland to scrub is thought to have benefitted small mammals by providing them with shelter from predators. In turn, their habit of burying haws during winter may have assisted scrub invasion.

Downland plants Despite the invading scrub the rich downland flora still exists where conditions are suitable, and it is still one of the treasures of the Estate. From March to October there is a succession of plants including hairy violet, rock rose, kidney vetch, pasque flower and six species of orchid. Some of these plants are rare on the Estate–as they are nationally. It is usually easy to find as many as 20 wild plants growing in a square metre on this downland, many–like the three species of gentian–having their own peculiar

Above: Young leaves of whitebeam opening in spring.

Right: The chalkhill blue, feeding on a flower of bird's-foot trefoil.

Below: Primrose and bugle are two spring flowers common at Ashridge.

niche. The early gentian appears in June and is usually only 5cm (2in) in height. It grows only in the short turf. The more robust autumn gentian can be seen over much of the downland in August and September but the Chiltern gentian, which often grows over 15cm (6in) high, is only found where the soil has been disturbed comparatively recently.

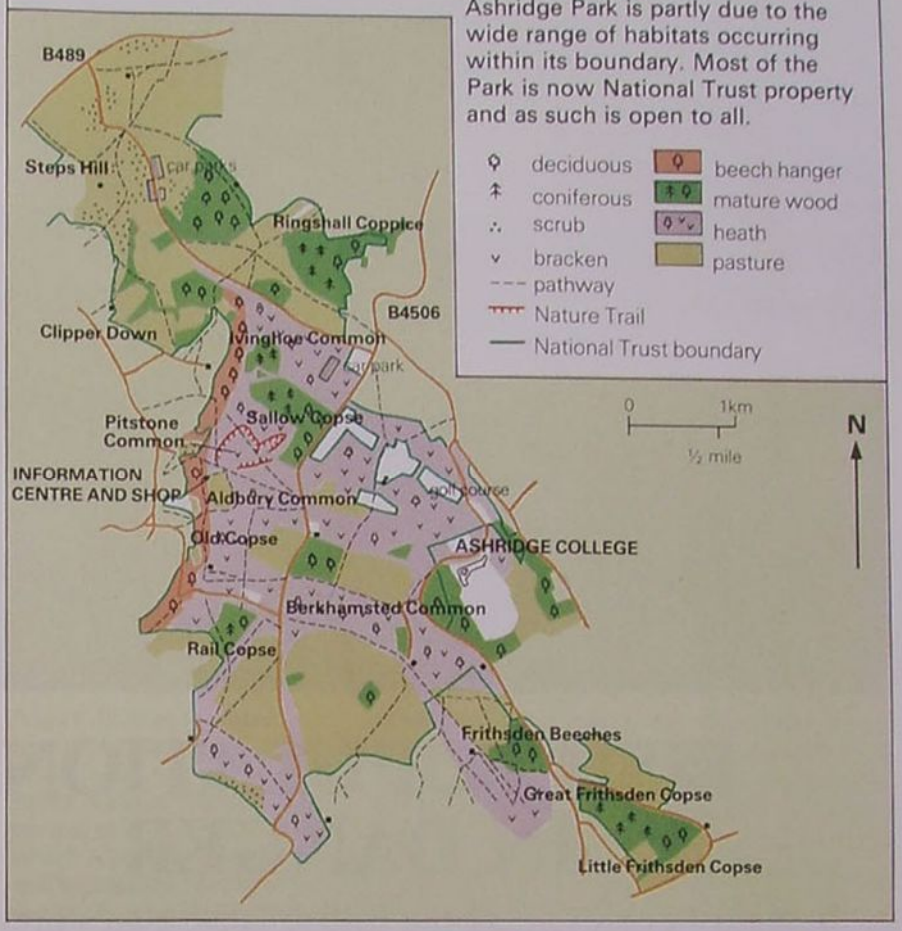
Downland butterflies Because of the profusion of flowering plants the downland also supports a variety of insects. Notable are the butterflies that appear in early summer, including the common blue, small blue and Duke of Burgundy fritillary. Late summer brings the marbled white and dark green fritillary and finally, towards the end of summer, the beautiful chalkhill blue. This butterfly roosts at the top of grass stems as evening approaches and may become quite tame as the chill evening air prevents it from flying. The chalkhill blue is still plentiful, although in wet summers it is hardly ever seen on the wing.

The future A bird census of the Ivinghoe hills conducted by the British Trust for Ornithology in 1966 found that on land previously grazed, where hawthorn was beginning to take over, there were no fewer than 37 different bird species breeding in an 80ha (200 acre) sample plot; a far higher density than on arable land or most woodland. The great difficulty for the continued successful management of any area of downland is finding the correct balance: many of Ashridge's rarest species require short downland turf, the maintenance of which needs constant clearance and the introduction of grazing animals. Yet overgrazing would lead to erosion of the soil. Achieving this balance is now the aim of conservation bodies involved with this and other sites.

In the meantime Ashridge Park continues to provide pleasure and recreation for people coming from miles around.

The Estate

The great variety of life found in Ashridge Park is partly due to the wide range of habitats occurring within its boundary. Most of the Park is now National Trust property and as such is open to all.



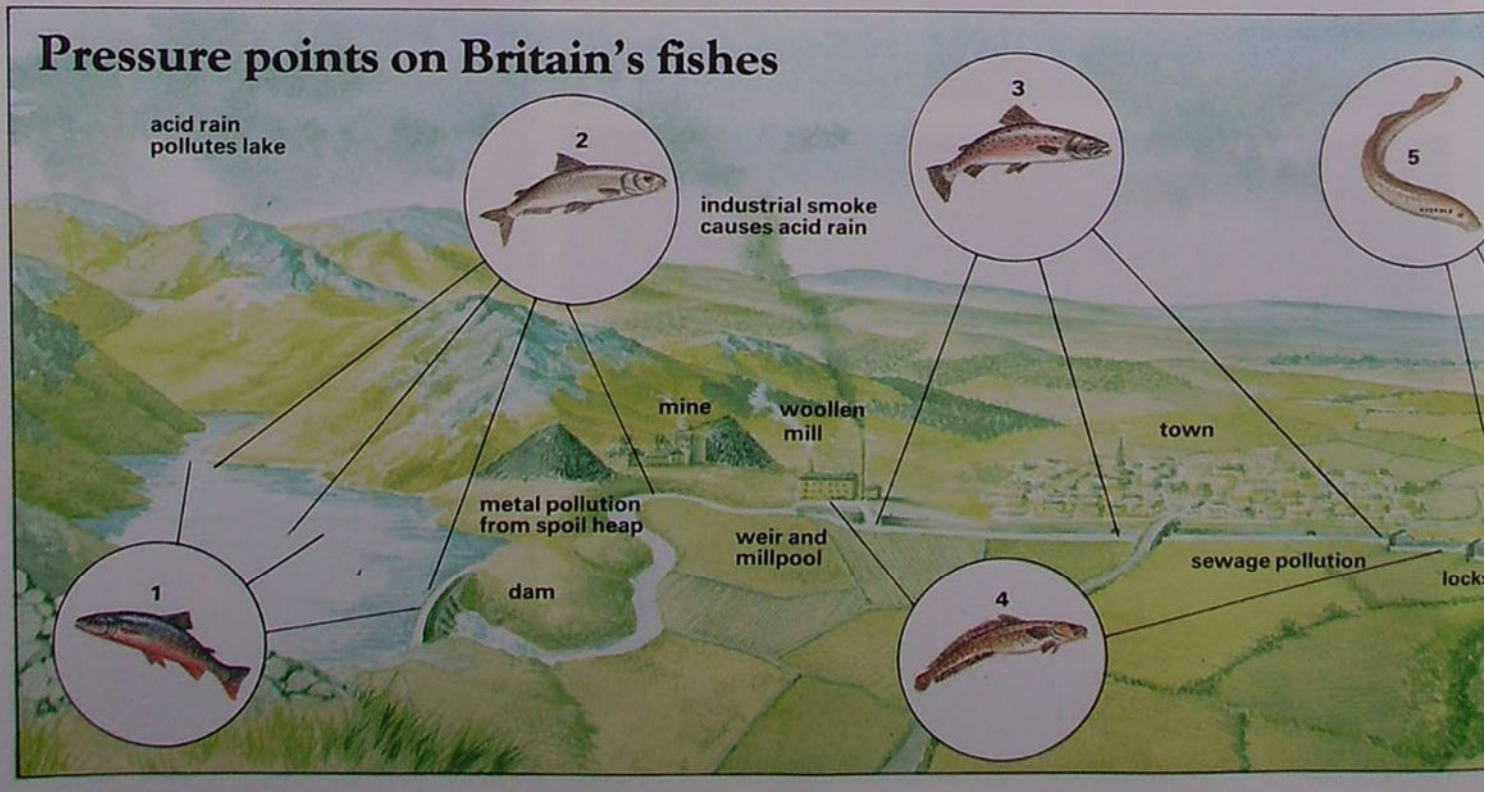
Right: The rare Chiltern gentian growing among the short downland turf at Ashridge.

Below: A jay broods three nestlings. Jays hoard large numbers of acorns, some of which they lose–a habit that helps to spread new oaks, thus replacing old felled trees.

FISH POPULATIONS IN DANGER

In almost every part of the British Isles, man's presence has had profound effects on the natural environment. Plant and animal species that were once common have become rare or even extinct, while numerous introductions, formerly unknown, now thrive. Here we look at factors affecting fish populations.

Above: Weed cutting on the River Avon in Hampshire. This is done in order to smooth the flow of the river, which makes it drain the land better and improves its agricultural potential. Weeds are removed from the river bed as well as the banks. This reduces available food and shelter for fishes, the young being especially affected. Dredging, too, improves the river's drainage at the expense of fishes.



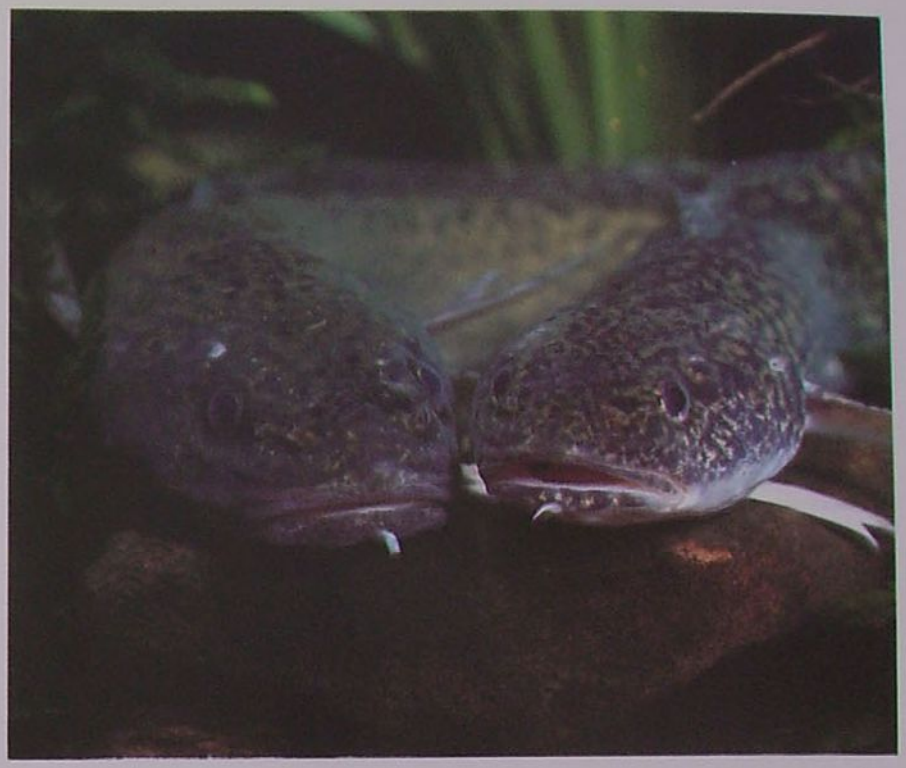
A good deal is known about the effects of environmental change on such animal groups as birds, butterflies or mammals, as well as plants (particularly flowering ones) but the same cannot, unfortunately, be said for fishes. In aquatic habitats, observation is relatively difficult, and we know rather less about what has been happening. As a result, the conservation of fishes has lagged behind that of many other animal groups (and certainly the other vertebrates), and much of what has been written has taken the form of case histories of some decline or extinction which has already happened. These have shown that there are as many pressures on our native fishes as there are on any other group.

Taming the rivers As fishes depend on water for their existence, so they are affected by human needs for water. Since even before the Industrial Revolution, man has been using dams to exploit the flow of river water as a source of power. The damming of a river is usually undertaken for one simple reason–it enables engineers to direct the water's flow through a channel where it can be used to drive a paddle wheel which produces power. For wildlife, the consequences of this simple act are considerable. First, it alters the flow characteristics of the river, converting it into a deeper, almost still-water environment upstream and shallows with perhaps a narrow channel downstream where the water may in places be turbulent. The changed flow affects many aspects of fishes' lives, from egg-laying to food availability. It also impedes the passage of migratory fishes up and down the river, and often makes them more vulnerable to capture during their passage.

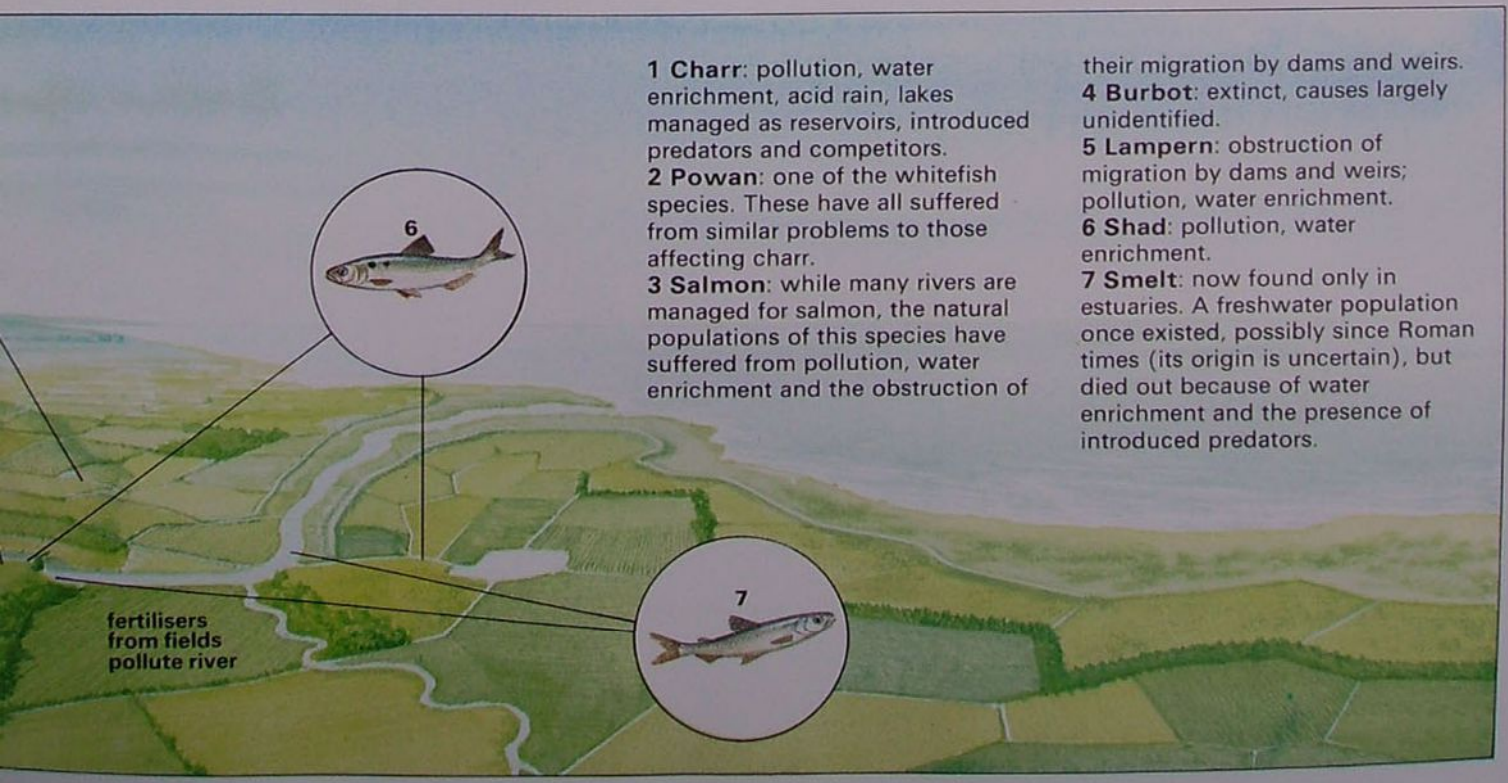
Rivers are also used for navigation and, at least historically, were important means of transport for heavy loads. Navigation thus imposed further changes on our rivers. Their beds were dredged of gravel shallows to provide a deep and even channel for boats. Where the gradient was steep, weirs were built to hold back the water, incorporating locks to enable boats to pass.

The needs of navigation also led to the construction of canals, which linked virtually all the rivers of the United Kingdom together, with the exception only of those in the extreme west and north.

Draining the land The reclamation of land from fenlands and other low-lying areas has



Above: Burbot are now thought to be extinct in the British Isles. Conservation of fishes is the responsibility of several official bodies, all of which have other pressing, and sometimes conflicting duties. At least the factors which affect fishes adversely are now clearly identified, which is the first step towards the start of a possible programme of fish conservation. But the burbot is lost already.



1 Charr: pollution, water enrichment, acid rain, lakes managed as reservoirs, introduced predators and competitors.
2 Powan: one of the whitefish species. These have all suffered from similar problems to those affecting charr.
3 Salmon: while many rivers are managed for salmon, the natural populations of this species have suffered from pollution, water enrichment and the obstruction of their migration by dams and weirs.
4 Burbot: extinct, causes largely unidentified.
5 Lampern: obstruction of migration by dams and weirs; pollution, water enrichment.
6 Shad: pollution, water enrichment.
7 Smelt: now found only in estuaries. A freshwater population once existed, possibly since Roman times (its origin is uncertain), but died out because of water enrichment and the presence of introduced predators.

been proceeding for several centuries, and many of the 'drains' of the eastern parts of England are man-made rivers whose original function was to rid the land of water so that agriculture was made possible. More recently, agricultural interests have been highly successful in enforcing the view that rivers are merely channels for the better drainage of land (although their water is also used for irrigation in drought!).

Polluting the water Other factors can alter the nature of the aquatic environment. The addition of fertilisers to the land produces enriched water, mostly from nitrates and phosphates, in rivers and lakes which in turn stimulate plant growth. In the short term this is not a serious matter; in the long term it may spell disaster, especially in lakes, for the death and decay of excess plant life leads to a decline in water quality and eventually to the deterioration of the lake into a swamp.

The effects on the animals which live in the lake are serious. Such enrichment (technically known as eutrophication) occurs when inadequately treated sewage, either from farm animals or humans, is discharged into a river or lake. Such discharges have already resulted in disastrous pollution in many rivers in heavily populated parts of the British Isles.

This process has often been complicated by the discharges of toxic wastes from industry. While much of such industrial pollution was confined to the urban areas in the past, it has never been exclusive to them: copper mines in rural Wales and lead mines in the Lake District produced serious local pollution.

Acidification of lakes, especially in areas where the underlying rock is granite, is also a problem in many parts of the Northern Hemisphere, although only relatively recently recognized as such. Excess acidity is produced by the sulphur contaminant in fossil fuel burnt by industry being carried by the wind and deposited by 'acid rain' as sulphuric acid onto the land. In serious cases, lake water is so affected that no animal life is found.

Fishes most affected These, then, are some of the problems which have affected fishes in the British Isles. It is obvious that they apply to some kinds of fishes more than others, for most of our rivers and lakes still hold substantial stocks of fishes. One whole category of fishes that have suffered is the migratory species that spawn in rivers and then descend to the sea to feed until the next breeding season.

The salmon is the best known of such fishes. There is no doubt that taken throughout the British Isles it has declined greatly due to obstructions in rivers, pollution and eutrophication. But its decline has not been so dramatic as that of the less well-known lampern (*Lampetra fluviatilis*) and the twaite and allis shads (*Allosa fallax* and *A. alosa*). All three species are now rare except in the rivers of the south-west, the Severn system being the stronghold of shad and lampern (and salmon) in Britain, as the Shannon is in Ireland.

The most vulnerable of all our native fishes are those which live in restricted habitats and are confined to them. Of these the whitefishes (*Coregonus* spp.) and the charr (*Salvelinus alpinus*) populations of Ireland, northern Wales, north-west England and Scotland, are the most seriously threatened. They are under pressure from eutrophication, pollution, excess acidity, the introduction of predators and competitors, and the use of the lakes for water storage, although fortunately not all at once! Nevertheless, one population of whitefish and several populations of charr have become extinct in historical times.

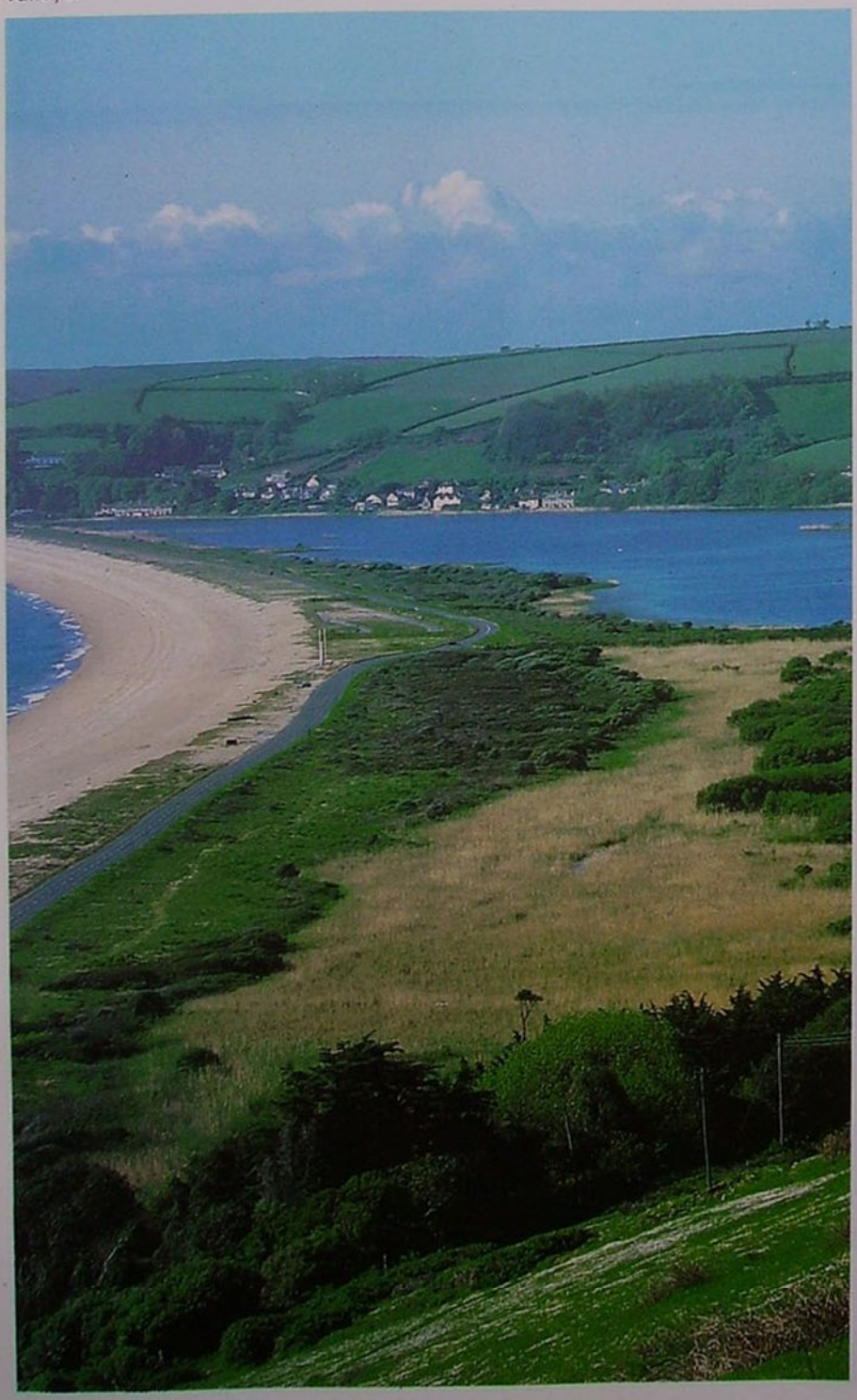
In lowland Britain the burbot (*Lota lota*), formerly found only in eastern England, is now believed to be extinct although the cause of its loss is not clear. Gone, too, is the unique population of smelt (*Osmerus eperlanus*) which lived in Rostherne Mere, Cheshire. This was remarkable in that it was the only freshwater population of the species in the British Isles.

Above: This system of conical traps is known as a putcheon weir. The traps catch salmon and other fishes as they migrate upstream to breed. Clearly it is an efficient trapping system and it is not surprising that it has reduced natural salmon stocks.

Below: Management of a trout stream involves removing competitors and predators (usually pike). Here unwanted fishes are being temporarily stunned with electric currents and then lifted, still alive, from the surface in nets. They are not killed but transferred to other waters. However, they may cause problems there, both by competing too successfully with native fishes and possibly by introducing diseases.

SLAPTON'S CHANGING ECOLOGY

The natural rate of ecological change in a lake is slow, but human influence and chance events brought rapid and dramatic change to Slapton Ley.



Below: Slapton Ley, showing the Lower Ley (open water) and the Higher Ley, which appears as a brown area in the foreground. The Higher Ley is largely dominated by *Phragmites* reed swamp and floating islands of willow and alder carr. The Ley was formed about a thousand years ago when a shingle ridge, thrown up by the sea, impounded a river. The picture also shows that the catchment area of the Ley is hilly, dominated by mixed farming, with wooded valleys.

Situated in the picturesque South Hams area of South Devon, on the coast between the River Dart and the Kingsbridge Estuary, Slapton Ley (the second word is pronounced 'lee') is the largest natural body of fresh water in south-west England. It is divided into two basins, the Higher and Lower Leys, linked by a channel and separated from the sea by the 3.5km (2 mile) long shingle ridge. The surrounding wetland area extends over 116 hectares (280 acres) and the lake itself is shallow, with an average depth of 1.5m (5ft).

Fishes of the Ley Records of the fishes go back to the 14th century, when it is believed that priests from the chantry in the nearby village introduced and fished for pike there. In the 19th century the Ley was renowned in the sporting world as a pike fishery, but good catches of perch and rudd were also made. The Ley attracted tourist fishermen of those times from far afield. Although not numerous enough to be of great sporting significance, a few roach were also present.

Fertiliser run-off The increase in the use of fertilisers over the post-war decades has had a marked effect on the lake. Nitrates added to the neighbouring fields have leached out into the streams and so to the lake. Improved drainage of the fields has intensified this effect, making the Ley more productive of plant and animal life than ever before.

The effects of such accelerated biological production, known as eutrophication, are very noticeable in a small, shallow lagoon. The richness and abundance of the plant plankton have increased, and now the Ley regularly becomes pea-green in summer as the plant plankton blooms, a phenomenon unknown there until the 1970s. Many rooted water plants are also becoming denser in the shallow bays. In these conditions, roach have fared much better than other fishes and, whereas this was a poorly represented species prior to the 1960s, throughout that decade it increased in numbers. By 1973 it was the dominant fish in the lake.

A year later the rudd population had virtually disappeared, driven out by competition with the roach, as has happened in so many other places where these two species occur together. The perch population had also declined in numbers, again probably because of competition with the roach, and even pike, though numerous, were small and good-sized specimens were exceptionally rare. When the roach first started to increase, the growth of individual fishes was good, but by 1973 they were so numerous that competition between individuals had led to poor growth rates and an overcrowded population of small, stunted fishes.

Grebes on the lake The birds of the Ley were initially unaffected by these changes, and numbers remained fairly steady despite small yearly variations. One or two new species of warbler took up residence, but the most significant change was in 1972 when a pair of

Left: This view of the Lower Ley shows the development of algae and other aquatic plants as a result of enrichment by farm fertiliser in the drainage system. All shallow, productive lakes tend to become gradually more productive as plant matter accumulates; in Slapton Ley the fertiliser has speeded up the process dramatically. Eventually the Ley is likely to fill in and become dry land.

Right: A shoal of rudd. At one time this was probably the characteristic fish species of the Ley. It may even have been the dominant species before priests introduced pike as a food source in the Middle Ages. Competition from roach has affected rudd badly in recent times.

great crested grebes visited the lake. Although great crested grebes are believed to have bred on the lake in the 1930s, in later years they were only occasional non-breeding visitors.

In 1973, however, one pair bred for the first time in decades, and great crested grebes have bred on the lake every year since. Their numbers appear to have stabilised at between five and seven breeding pairs. The arrival of the grebes was part of the natural extension of their range that took place in the post-war decades, and was thus a natural, chance colonization.

Arrival of a worm The grebes brought with them, again as a chance event, three species of fish parasite. The most important of these as far as the ecology of the lake was concerned was the tapeworm *Ligula intestinalis*. As an adult, this can infect any species of bird, in which it lives for no more than a couple of weeks while it produces eggs. The bird sheds the eggs into the lake, and these hatch into larvae that infect small crustacean animals known as copepods. Infected copepods are in turn eaten by fishes. Any fish can eat them, but the parasite can only develop further in roach and bream and, in some lakes, rudd.

In Slapton Ley only roach have been infected by the tapeworm larvae, and rudd have always proved to be free of the parasite. In the roach the parasite develops into another larval stage in the body cavity, where it can live for several years, or as long as the fish lives. It can attain a weight of up to a quarter of that of the fish. It is also a very dangerous parasite for its host. It causes the fish to become sterile and incapable of breeding. In addition it affects its shape and stamina and so makes the infected fish selectively more vulnerable to predation by fish-eating birds, thereby increasing the chances of completing its own life-cycle.

Right: A great crested grebe nesting on the shore. From its point of view, eutrophication was a stroke of luck, for it resulted in large numbers of small roach– which happen to be suitable prey for the grebe.

Opposite bottom: The roach is now the dominant fish species in the Ley.

Below: Besides algae, reeds grow well in the enriched conditions of the Lower Ley. The Higher Ley is virtually one large reedbed already.

Only one *Ligula* was found in 1973, but the population of the parasite increased very rapidly until by 1975 a third of all the roach in the Ley were infected. The *Ligula* in Slapton Ley appears to be particularly harmful, as all infected fishes are either caught by predators or die from other causes by the age of three.

Changes in fish sizes This thinning of the roach population by *Ligula* led to an improvement in the growth of surviving roach, as the competition between individuals was reduced. This was evident as early as 1976, and the growth rates have improved every year since, until now they are as good as almost anywhere in the country. The decline in the roach population has also reduced the competition with rudd, and this species has been recovering from its decline; good catches of rudd were recorded again in 1975 and 1976.

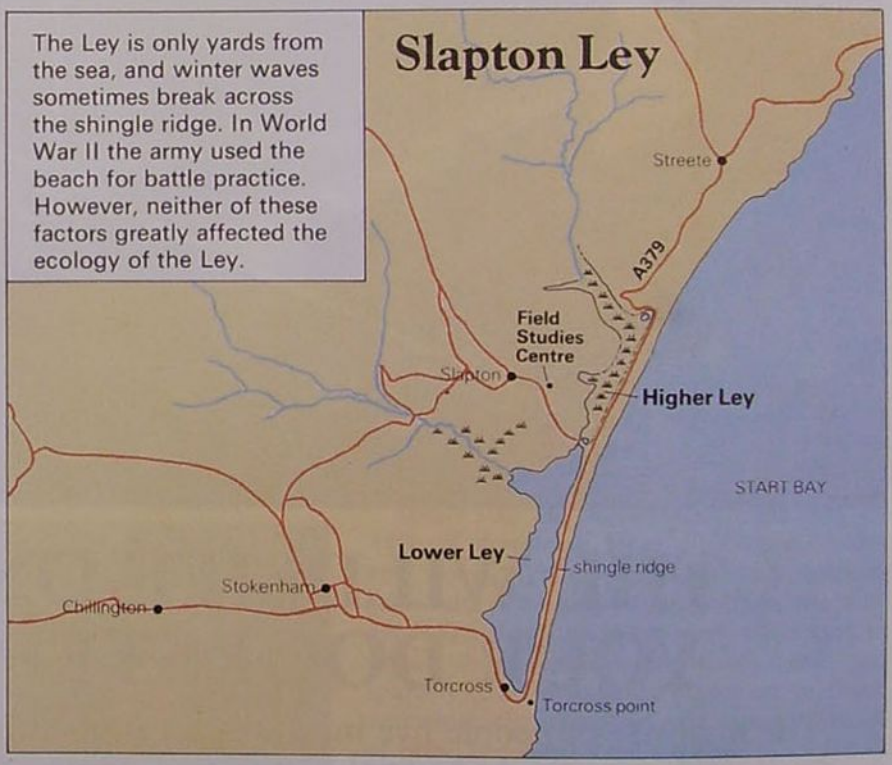
Perch were slower to respond to the reduced competition from roach, but their numbers are also increasing again and their growth rates are also improving. Anglers are now also beginning to catch large pike once more. At present, *Ligula* levels seem to be on the decline but the parasite is still present and having an effect.

The future of the Ley Other recent changes in the lake have been minor compared with eutrophication and the advent of *Ligula*. Mink have colonized the reeds, but co-exist with otters, for which the sheltered and undisturbed reserve is a good site. Some rare species of birds have appeared, despite the presence of mink; the only other newcomers are the two other species of fish parasite brought by the grebes, which have had little or no impact on the balance of species.

However, it is no exaggeration to say that the food web in the lake–and therefore the balance of species in the whole community–depends on the fishes, and the balance of fish species in turn depends on *Ligula*. Any change in *Ligula* levels will thus affect the whole lake, but it is not yet clear what controls these levels, or what will happen in the next few years. *Ligula* could disappear, allowing roach to become numerous again at the expense of rudd; or it could increase again, and cause roach to disappear altogether, while rudd would then return to their earlier dominance. Alternatively, the balance between the two species might swing from one side to the other, and back again, in an oscillating pattern. Time alone will show.

The present situation is the result of a chain of interconnected events. Fertiliser favoured roach, which led to their stunting, which in turn favoured grebes (although the appearance of grebes and *Ligula* was due entirely to chance). The changes in the last 20 years have been more rapid and dramatic than at any other time over the centuries, and undoubtedly the principal agents of change have been farm fertiliser and the chance arrival of a pair of birds and a parasite.

The Ley is only yards from the sea, and winter waves sometimes break across the shingle ridge. In World War II the army used the beach for battle practice. However, neither of these factors greatly affected the ecology of the Ley.



THE WILDLIFE ON YOUR DOORSTEP

The majority of people live in towns, most of which have developed since the Industrial Revolution. Dense Victorian terraced housing and factories, larger suburban homes that sprang up in the interwar years, and modern high rise blocks all provide a home for assorted species of wildlife.

Above: Herring gulls, which normally nest on cliffs or isolated cliff-top grasslands, are now adapting readily to the abundance of flat and sloping roofs of factories and high-rise flats. Although they are a relatively recent arrival on the urban scene (before 1940 urban nesting herring gulls were comparatively rare) they are now a major problem in some coastal towns. The chicks in this picture have hatched on a roof in the centre of Aberdeen. Here and in other towns and cities one of their favourite sources of food will be the municipal rubbish dump, where they often gather in noisy flocks.

It is a common misconception to think of large cities, with all their inherent problems of noise and congestion, as a 20th century phenomenon. As long ago as the third century AD Rome had a population of about a million people, with associated difficulties of noise and traffic. Since urban habitats have been available for so long, it is not surprising that many animals and plants have established themselves in towns and continue to do so as towns expand and change.

Man-made cliffs One of the most obvious features distinguishing a city from the countryside is its buildings. These may be offices or homes to their original builders, but are regarded as good substitutes for a variety of natural habitats by other species. Tall offices or warehouses make ideal inland 'cliffs' and are treated as such by a number of birds. The ubiquitous town pigeon, for example, is

descended from the rock dove, an inhabitant of wild, rocky coasts, so it is not surprising that this species does well in towns and cities. Herring gulls find roofs an ideal habitat–the proof is that urban gulls often breed more successfully than their more traditional relatives, quite possibly because of the abundance of food from refuse tips.

Another, somewhat more unusual gull to move into some towns is the kittiwake. It is generally one of the gulls least associated with man, spending the entire winter far out at sea, only returning to land in spring to breed in cliff-ledge colonies. However, in cities such as Newcastle-upon-Tyne, it is beginning to use ledges on deserted warehouses as substitutes for cliffs.

Although gulls may be relatively recent newcomers to towns, other birds have been associated with man's dwellings for so long that in some cases this relationship is reflected in their common names. The house martin is a familiar nesting bird in towns, plastering its mud and spittle nests under eaves or against rafters in outhouses and garages. It is quite likely that the abundance of nest sites provided by the development of towns has allowed its population to expand.

Wall life A great variety of plants have taken a roothold in the crumbling mortar of old buildings and walls. Ferns, such as the rustyback, and flowering plants, such as ivy-leaved toadflax, are common while the curious wall pennywort grows on shaded walls in the south west. Many introduced species have become naturalised on walls. Nor is it just relatively recent walls that are invaded: the tiny fairy foxglove, a favourite alpine of gardeners, is established in places along Hadrian's wall. A more widespread introduction to walls and old buildings is buddleia, a native of China. Despite its size, it can cling to the narrowest of ledges. By providing a copious supply of nectar for red admirals, peacocks, small tortoiseshells and brimstones it is now a welcome and integral part of our urban ecology.

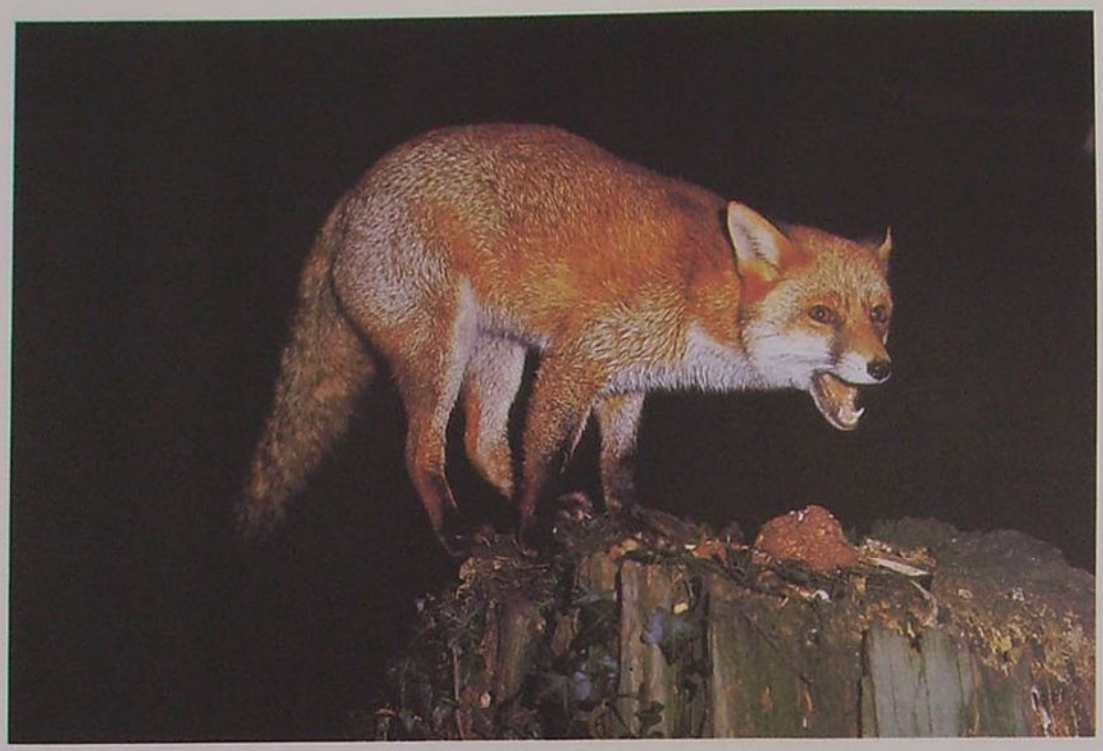
Above: The grey squirrel is a common mammal in many town parks and is sometimes seen in larger suburban gardens, particularly those that were built in the interwar years which now have tall, mature trees.

Below: Badgers are becoming more common in some cities, although animals as tame as this one are unusual. Many travel quite long distances between a town and the surrounding countryside.

Walls are also a home to a wide variety of different insects and other invertebrates. Many are there for the foodplants, while others are merely using the physical features of the wall. The mid-summer generation of holly blue butterfly feeds on ivy which clothes many walls in suburban areas. Underneath the ivy are insects, woodlice, springtails and spiders, many living just as they would if they were under ivy cover in woodlands.

Snails too are widespread, especially on walls of limestone. Here they derive shelter and food from the plants and calcium carbonate for shell-building from the wall itself. Snails will also rasp away whitewash to obtain this chemical. On sunny, new and sparsely covered walls the highly active, black and white striped zebra spider roams in search of prey. It uses its keen eyesight to locate its prey then, like a miniature cat, stalks it, covering the last couple of centimetres in a rapid leap. It is of course a member of the jumping spider family, Salticidae. One of its relatives, *Segestria florentina*, an introduced species originally from southern Europe, is now well established on walls in a number of ports. It lives in crevices or holes which it lines with a silken tube. At its open end the tube splays out in a fan of threads over the wall. As the tripwires are triggered, the spider darts out of the tunnel to seize its hapless prey.

Inner city life As cities grow at the edges, so the central areas often fall into disrepair. Here and on other derelict ground many urban plants and animals do well. For instance, unlike the woodland-dwelling common red-

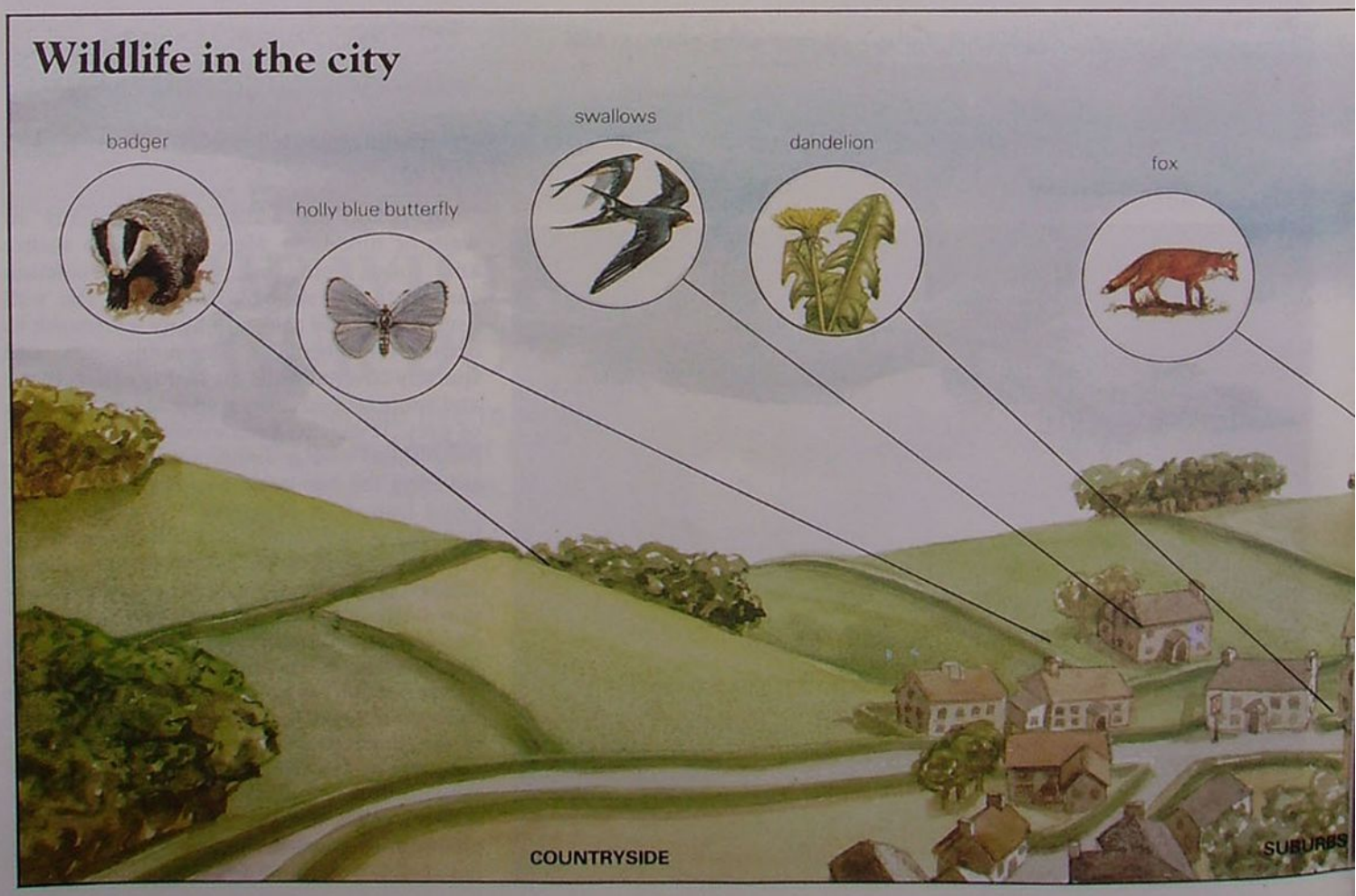


Left: Today's distribution of urban foxes reflects the development of our towns. They are most common in southern England in affluent dormitory towns. In the north and Midlands they are least common in industrial cities where housing density is high with small gardens. For example, in the West Midlands conurbation foxes are common in Solihull and parts of West Bromwich, Birmingham and Dudley, but much rarer in the industrial parts of Dudley and the heavily industrialised areas of Walsall and Wolverhampton. You are probably less likely to see an urban fox in areas where there are large numbers of stray dogs.

start, the black redstart is very much a creature of open rocky ground. It was quite common on blitz-damaged sites in London and is now found on derelict city sites throughout Europe.

These areas soon develop a characteristic flora. The stinging nettle, for example, favours rich soils, particularly those that were well fertilised in the past. It is an important species in the ecology of urban environments and is well known as the foodplant of a number of attractive insects. Rosebay willowherb, ragwort, daisies and dandelions are speedy colonizers of any patch of land, and along with numerous garden escapes soon brighten abandoned areas.

Below: Some species of wildlife cannot penetrate further than the city suburbs, while others seek out any available niche to live and reproduce themselves–even a busy city centre.

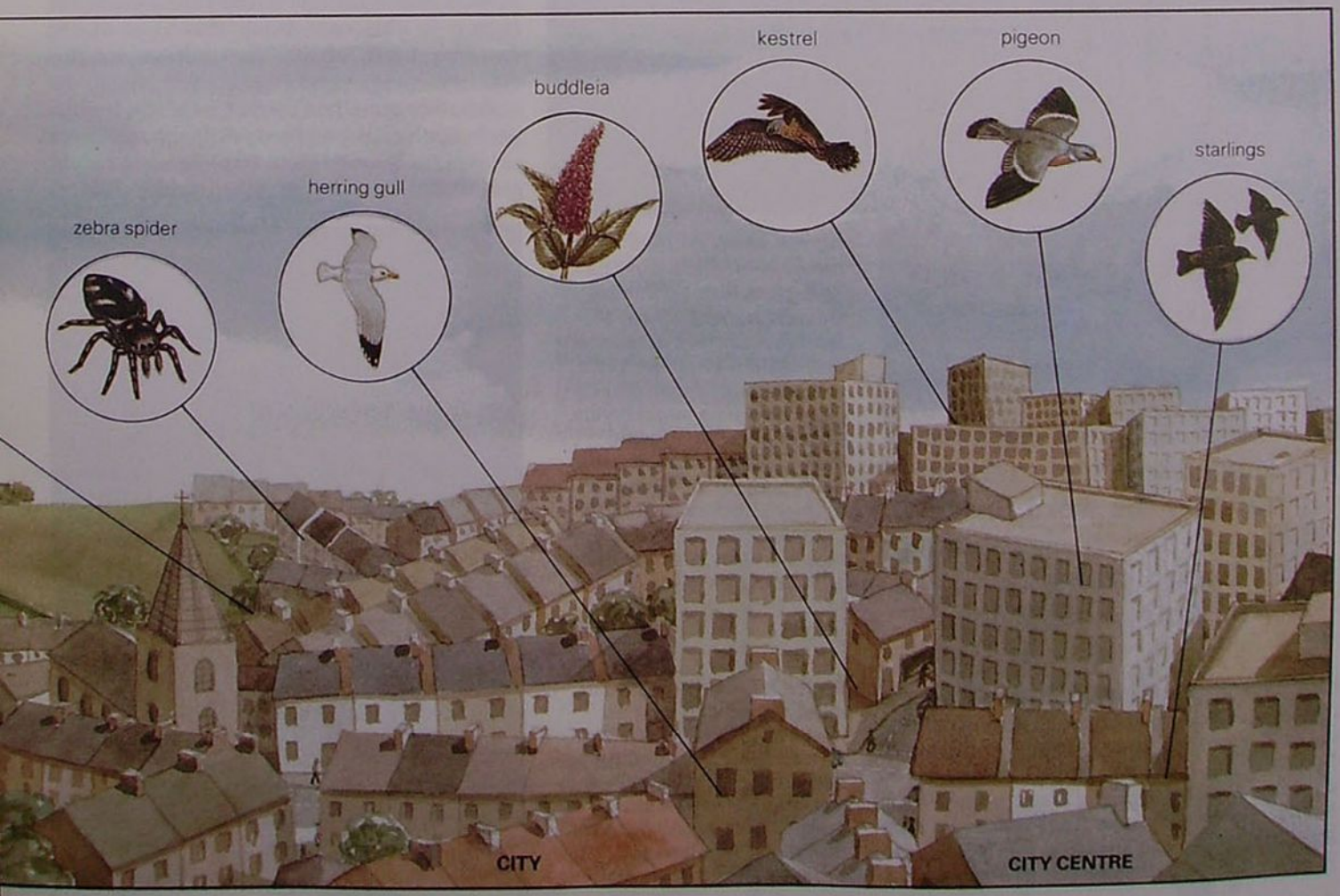


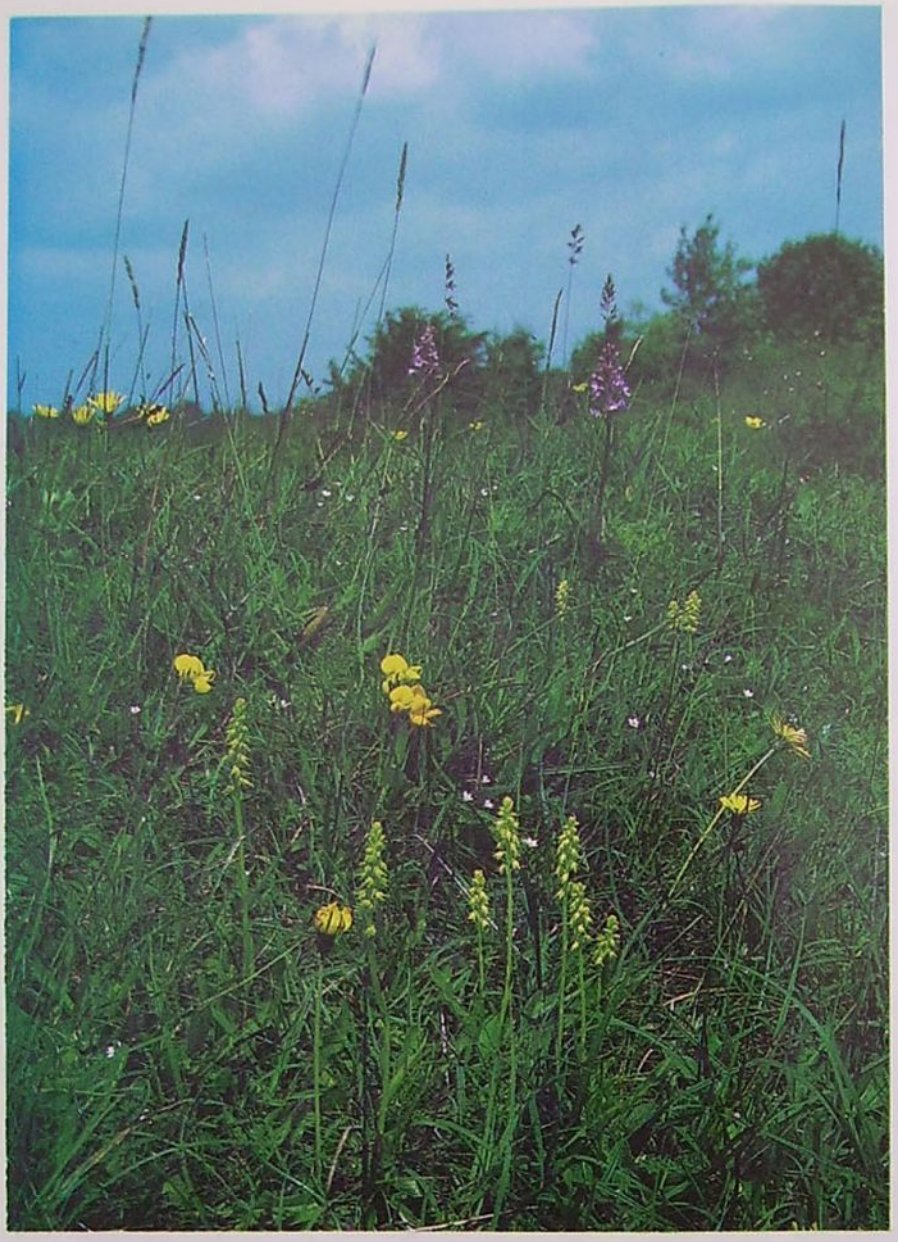
Garden life Gardens present a much more managed facet of urban ecology but nonetheless are extremely rich sources of wildlife. Particularly conspicuous are hoverflies such as the black and yellow, wasp-mimicking *Syrphus ribesii*, or the honey bee-mimicking species of *Eristalis*. Larvae of the former, like ladybirds, are the gardener's friend as they are voracious predators of aphids.

In the large gardens of the mid-1930s private housing developments, a wide range of birds are found. Most numerous are blackbirds, song and mistle thrushes, robins, wrens and blue and great tits, all of which are species that normally nest in bushes or holes in trees. Mature gardens, with enough space for trees and shrubs, provide abundant nest sites. Nestboxes and bird tables also encourage large bird populations. In old inner city areas where houses are smaller and packed together with small gardens, bushes and shrubs and trees are less frequent; here the most common birds are the house sparrow and starling, which nest in or on buildings. Although they are not considered glamorous their sociable natures means they are welcomed in the gardens of many town dwellers.

Tawny owls are sometimes found in areas of privately owned housing nesting high up in holes or in the forks of trees. As they move further into the city their diet changes from mainly small mammals in rural areas to small birds in city centres. Another conspicuous predator of today's cities is the fox, especially in areas of mature gardens. During the ribbon development of the interwar years plots of land were built upon at random, leaving tracts of rural land with isolated fox populations. As these areas were in turn developed, foxes moved into the surrounding suburbs and from there into city centres. Here, in addition to their normal diet, they take food put out for birds and, in affluent areas of some towns, high quality food is left for them. One Bristol resident owns a chain of steak houses, and the local foxes live on steak and cheese.

Above: Sparrows thrive in close proximity to man, and those that live in parks or gardens where they are regularly fed become very tame. They do best in the parts of towns where gardens are very small and there are few trees and shrubs. Like starlings and feral pigeons, they nest in or on buildings, using whatever material is available.





ORCHIDS INCHES HIGH

The single large bloom brought to mind by the word 'orchid' holds only for tropical plants. Some British orchids are tiny, often only inches high.

Above: Musk orchids growing on chalk downland. This plant is not common in Britain and retains just a tentative toehold in southern and eastern England, yet it sets plenty of seeds and can also reproduce vegetatively. Like many other small orchids (the musk orchid is rarely more than 15cm/6in tall) its size may mean that colonies go unrecorded and that the plant is actually more common than is realised.

Easily the smallest orchid in Britain is bog orchid which, along with the slightly larger fen orchid, shares a liking for very wet ground. Bog orchid is usually found growing on cushions of *Sphagnum* and is normally only 5-8cm (2-3in) high. Since bogs are often very large this plant is almost certainly Britain's most under-recorded orchid; it is simply not seen among the surrounding vegetation. The flowers of bog orchid are unusual in that the lip is at the top of the flower, whereas in most orchids it is at the bottom.

Fen orchid is one of our rarer species. It occurs in three distinct parts of the country: the fenland regions of East Anglia, South Wales and North Devon. In East Anglia it is becoming very rare indeed because of drainage, pollution and general disturbance of the habitat. In South Wales fen orchids can be found growing in dune slacks (the marshy areas behind sand dunes), and it seems to be consolidating its position in this habitat. In North Devon it has been known for some time to be growing in an area of dune slack, so it seems that dune slacks are a better habitat for fen orchids than the fens after which it is named.

Both bog and fen orchids have a feature unique among British orchids: the possession of a pair of pseudobulbs at the base of the plant acting as storage organs. Pseudobulbs are of great interest to botanists because they are very common on tropical orchids, particularly those growing on trees.

Chalk and grass Changing environments completely, swapping the cold dampness of bogs and fens for the warm dry soil of southern chalklands, brings us to the habitat of another small, easily overlooked orchid–the musk orchid. Usually no more than 15cm (6in) tall, with numerous greenish-yellow flowers, this is another of our rare orchids, the reason in this case being that it is at the extreme limit of its distribution in this country.

Another grassland species is the small white orchid, which is exactly described by its name –it is usually only 15cm (6in) or so in height and bears a spike of small white flowers

Right: A flowering spike of musk orchid can bear as many as 20 to 30 individual flowers, each being roughly bell-shaped and deeply lobed. They have a strong scent of, not musk, but honey, for the flowers produce abundant nectar.

Left: A pair of bog orchids. At the base of each plant are two swellings connected to each other by a narrow stem. These are known as pseudobulbs and are storage organs. The lower of the two is last year's pseudobulb, covered with the remains of old leaves, while the one higher up is the present year's bulb, bearing two to five tiny leaves and a flowering spike. Each flower is extremely small and pale yellow or yellow-green.

(though they may sometimes be yellowish or even have a tint of green). The flowers have a very faint scent of vanilla. This orchid is found in hay meadows and on pasture and grassy areas generally, especially in hilly districts. Though in hayfields it grows among tall grasses, it seems most at home in short turf.

Pinewood species In the relict pine forests that originally formed the great Caledonian Forest you can find creeping lady's tresses, an orchid usually about 15cm (6in) tall. These very open forests have large spaces between individual trees, and in these areas this orchid is often plentiful, sending out creeping, branching runners through the carpet of pine needles. The runners bear upright flowering spikes, each about 10cm (4in) in height and carrying a dozen or more white flowers.

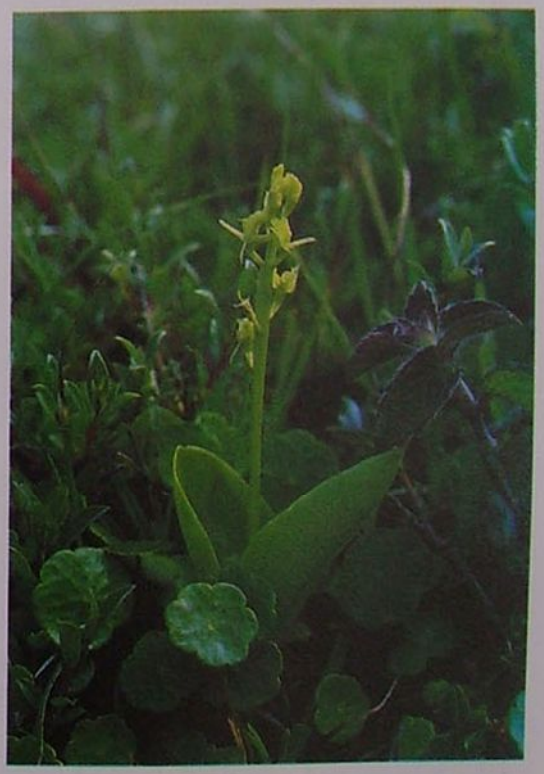
Creeping lady's tresses is very much a plant of northern England and Scotland where, as well as inhabiting pinewoods, it is also found in more mixed forest of pine and birch, and it sometimes tolerates growing among heather and other heathland shrubs. In the south of the country there are several populations of this orchid in the north of Norfolk, these plants probably having been accidentally introduced together with pine trees from Scotland.

Right: Our other small wetland orchid is the fen orchid, which is usually a little larger than the bog orchid. It too has pseudobulbs, the present year's bearing a flowering spike with anything from a single flower to a dozen, though four to six is normal. Most specimens have two broad upright pointed leaves but plants in the western part of the country have leaves that are broader and blunter. These plants form a distinct variety, called *ovata*. One is shown in this picture.

Visitor from Ireland One of our rarest orchids is the dense-flowered orchid. This plant is usually 15-20cm (6-8in) high, though larger specimens have been found.

Dense-flowered orchid has its centre of distribution in the Burren in western Ireland, an area of limestone pavement famous as the home of many rare plants. Before 1966 this plant was not known to exist in Britain, but in that year it was found growing on the Isle of Man. Such a migration of a rare plant– presumably on the prevailing westerly winds– is always a matter for excitement among botanists.

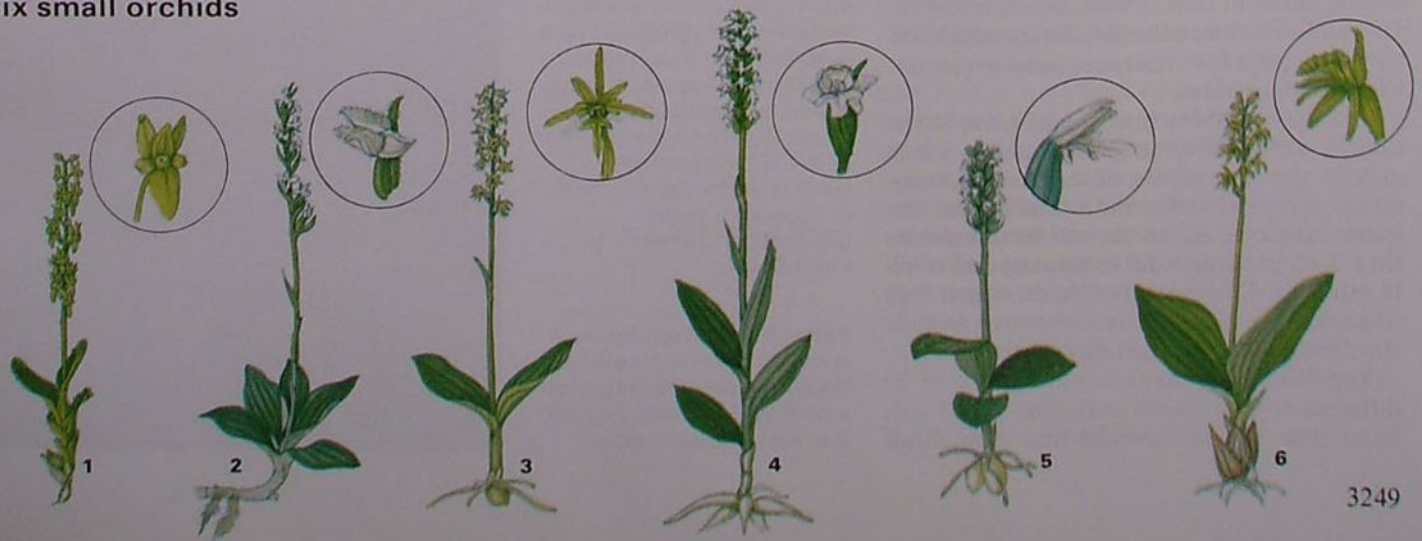
Dense-flowered orchid, and the other species mentioned, are characterised by being small and inconspicuous, and by a lack of colour. Despite this, however, they are beguiling plants, showing all the glamour of a large orchid in a small package.



Below: Our smallest orchids, shown here in rough proportion. The tiniest is the bog orchid at only 8cm (3in) tall.

1 Bog orchid (*Hammarbya paludosa*).
2 Creeping lady's tresses (*Goodyera repens*).
3 Musk orchid (*Herminium monorchis*).
4 Small white orchid (*Pseudorchis albida*).
5 Dense-flowered orchid (*Neotinea intacta*).
6 Fen orchid (*Liparis loeselii*).

Six small orchids



INSECTS OF THE FOREST

At least half of Britain's 30,000 insect species live in deciduous woods, yet this rich habitat is now threatened by the planting of conifers.

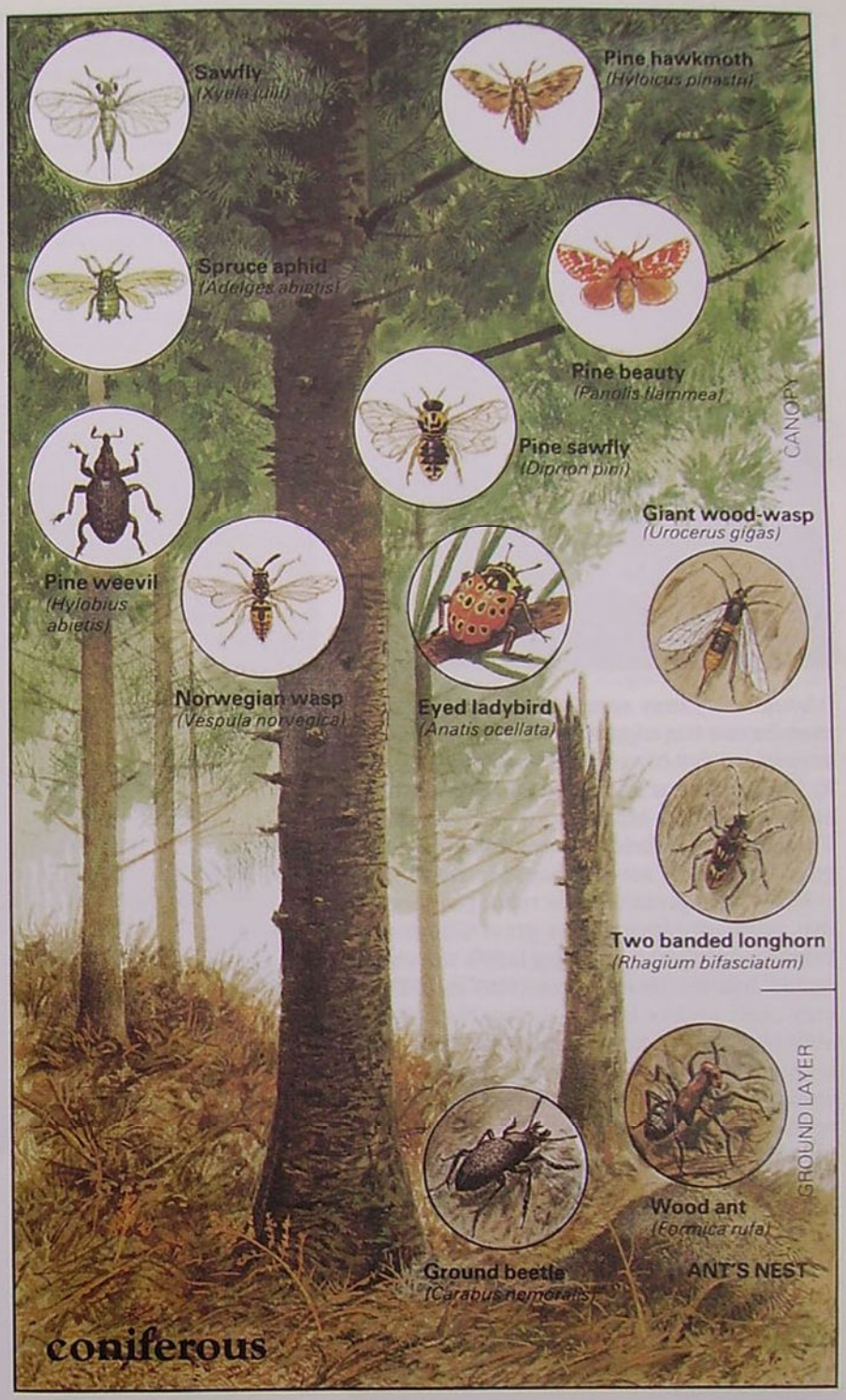
British woodland can be classified as either deciduous–dominated by trees such as oak, ash or birch–or coniferous, with trees such as pine, spruce or fir. The richest deciduous woods have a wide range of associated native plants and animals, and have existed (albeit in a highly managed form) for thousands of years. Similar long established native coniferous woods occur only in a few scattered places such as the Caledonian Forests of Scots pine and English and Welsh yew woods. However, the vast majority of British conifer woods have been planted this century and contain alien species such as Sitka spruce from the west coast of North America and Norway spruce from the Continent; even new plantations of Scots pine use Continental, rather than our own native stock.

At least half of Britain's 30,000 insect species depend upon deciduous woodland, which is hardly surprising when you consider that, but for man's clearance, most of Britain would be covered in such forest. Native deciduous woodland is able to support many more insect species than coniferous plantations, partly because our native British insects have had thousands of years to adapt to life in deciduous woodland and partly because there are many more places to live (niches) in a deciduous wood than in a coniferous wood.

A typical deciduous wood can be divided into four layers: tree canopy, shrub layer, field or herb layer, and ground layer, each containing different insects with different habits. Two additional woodland habitats which are very important for insects are dead wood and wide paths, or rides.

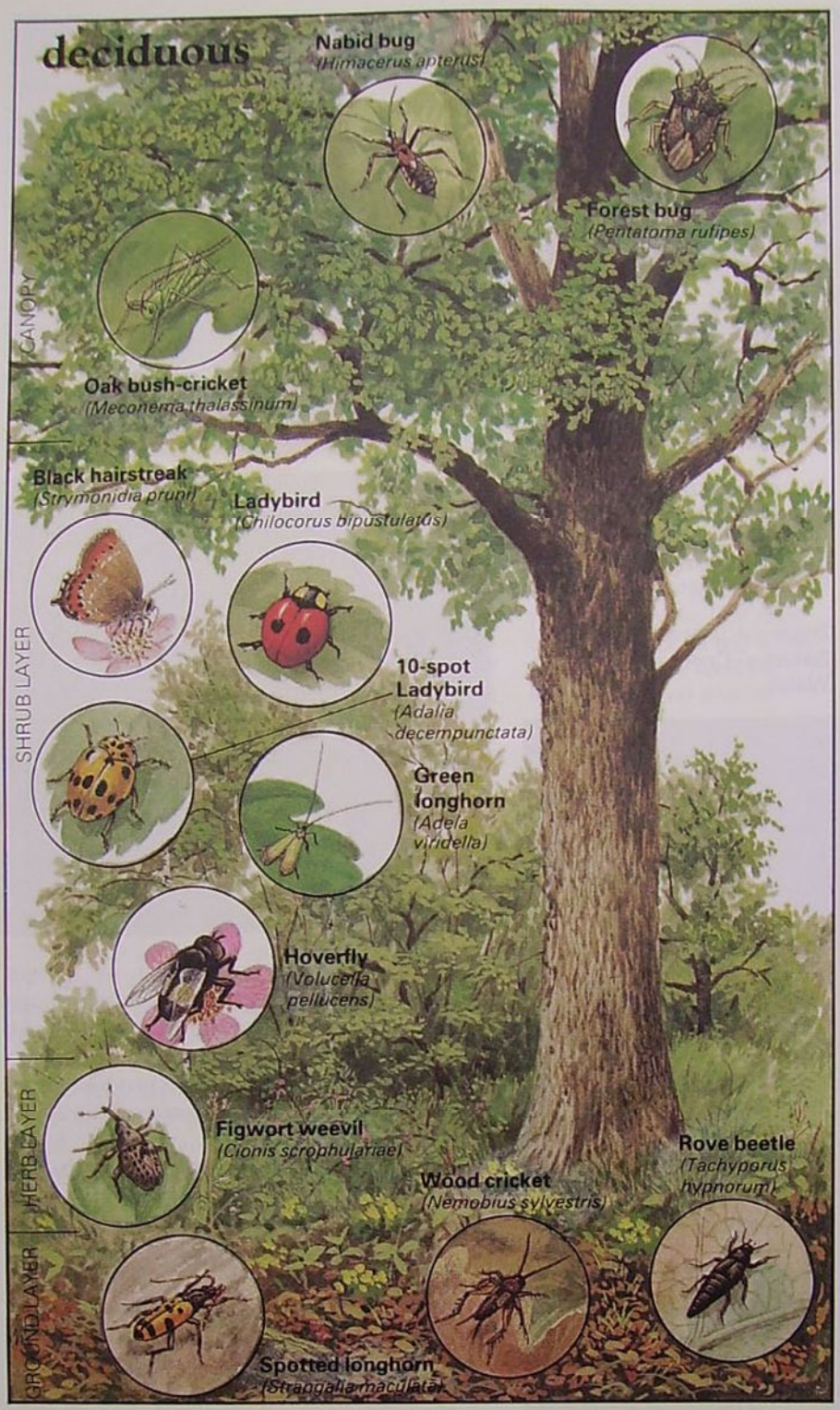
Leafy layers Many insects which live in the canopy are herbivores (plant-eaters). These include the caterpillars of such well-known moths as the oak roller and winter moths–the latter dangle on silken threads in summer as they drop to the ground to pupate, and catch in our hair. Carnivorous species, which feed on each other as well as on herbivores, include the delicate green or brown lacewings.

The shrub layer may contain as many as 20 different types of bush including hawthorn, hazel, dogwood and guelder rose. This shrub



Above: The coniferous wood lacks the rich shrub and herb layer found in a deciduous woodland. Thus the insects of coniferous woods are found largely on the ground or in the canopy–those feeding in the canopy have to cope with sticky, unpalatable chemicals in these leaves.

Right: Blair's shoulder moth is one of the few moths in Britain whose larvae feed on a conifer–Monterey cypress. It is now widespread.



Above: Deciduous woods support a much more varied insect fauna than coniferous woodland. Each layer within the wood has its own specialised feeders, some eating plants and others existing on other insects.

Left: Bark beetles, a group that includes the well-known elm-bark beetle, lay their eggs under tree bark. When the larvae hatch they feed on the inner layers of the bark, and the fungi found there, in so doing creating the patterns shown here.

layer is home to the caterpillars of several woodland butterflies: the brimstone–which depends upon alder or purging buckthorn as a larval foodplant; the spectacular purple emperor which lays its eggs on sallow leaves; and the rare and secretive black hairstreak which flies in blackthorn thickets close to the woodland edge. Ladybirds are among the many carnivorous insects which flourish in the shrub layer; the 7-spot and 10-spot ladybirds occur on a wide range of bushes, where they feed upon aphids. Nectar from flowering shrubs, particularly blackthorn blossom in April, is an important source of food to insects such as solitary bees.

Below the branches The range of spring flowers which adorn the floor of a deciduous wood is familiar to most people. The leaves or flowers of primroses, bluebells and celandines are essential as food for many insects. Our fritillary butterflies require leaves of violets as a larval foodplant while the weevil, *Cionus scrophulariae*, feeds on woodland figworts.

A profusion of small creatures occurs in the ground layer of deciduous woods, many being active only at night. The rich leaf litter provides food for detritus-feeders such as bristletails and springtails, while decaying and living plant tissues are food for millipedes and woodlice.

Many predators live on the woodland floor, including the fierce ground beetles with their sharp jaws. One of the largest is the violet ground beetle which is about 2cm ($\frac{3}{4}$in) in length. Other predators include spiders and harvestmen which feed on smaller soil animals. A special habitat is provided by fungi which are food for a group of flies called fungus gnats.

Dead wood and glades Standing dead trees also support a rich community of insects. Some, such as bark beetles, lay their eggs under the bark and their larvae eat the old bark or fungi which grow on the dead wood while others, such as the stag beetle, have larvae which burrow deep into the dead tree. Larvae of many beetles, including longhorn and cardinal, feed under the bark of mature trees, while the adults feed on flower nectar. Predators in this habitat include rove beetles, such as the devil's coach horse, and the ever-present spiders.

Rides and glades are important for insects as they provide both a strip of grassland and a large area of woodland edge. Rare woodland butterflies, such as the pearl-bordered fritillary fly along rides, feeding on nectar from bugle flowers and laying their eggs on, or near to, violets at the ride edge. Many hoverflies are found in rides where their high-pitched whine is familiar to visitors of deciduous woods. Some insects which are common in grassland, find their way into woods along rides. Good examples of these are the meadow brown and marbled white butterflies, both common along woodland rides.

Coniferous woods The typical mature con-

iferous plantation lacks the intricate structure of a deciduous wood: the canopy and ground flora are reduced and the shrub and herb layers are virtually absent. As a consequence there are relatively few insect species associated with coniferous woods.

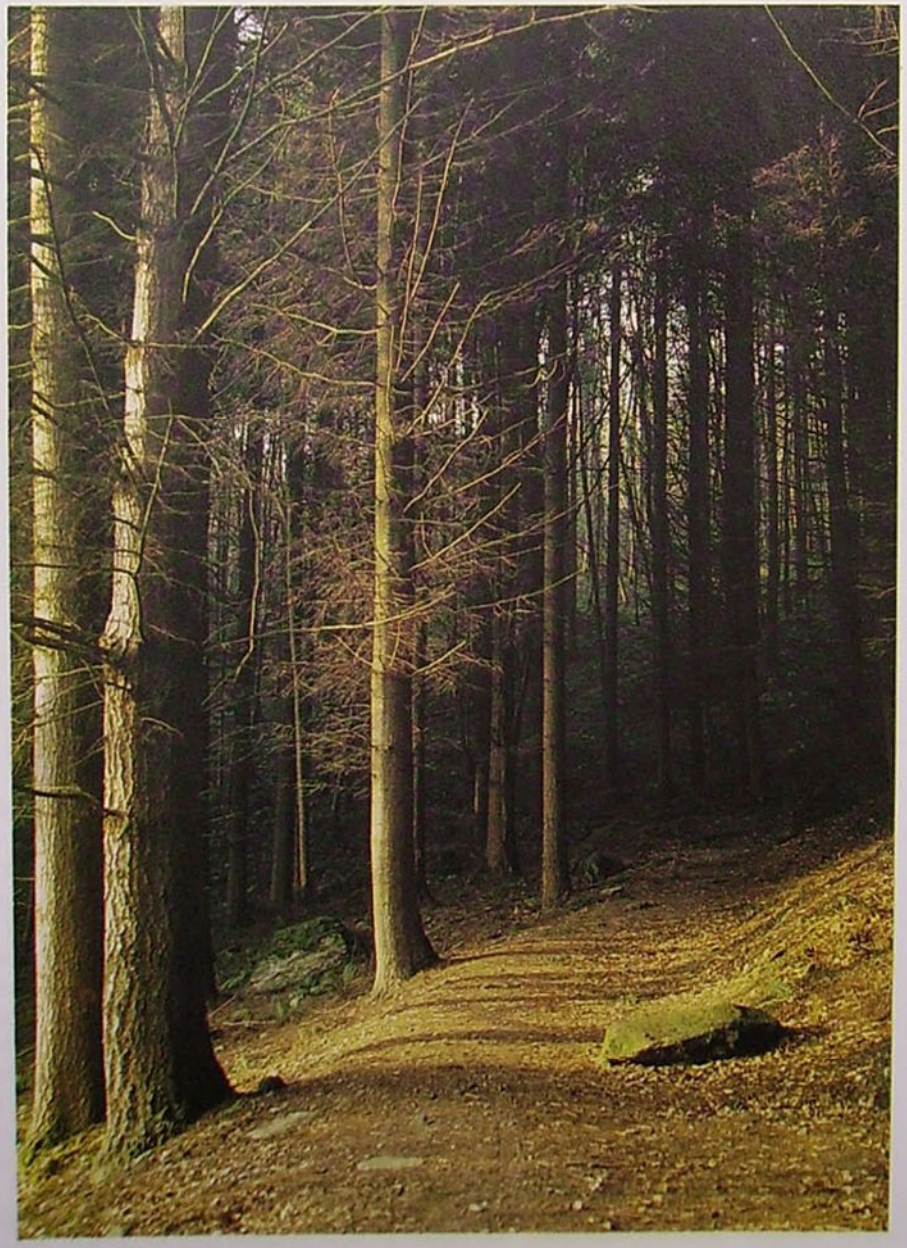
The needle-like leaves of conifers contain sticky, aromatic chemicals which have insecticidal properties; hence only specially adapted herbivores are able to feed on conifers. For example, certain moth and sawfly caterpillars feed on such trees by absorbing these harmful chemicals and storing them as inert substances. Moths such as the pine hawk and pine beauty feed on conifers, and in recent years the latter species has reached epidemic proportions in Scottish plantations of lodgepole pine. The probable reason for these outbreaks is that the shortage of insects in the canopy results in a lack of natural predators which would normally control their numbers.

A well-known canopy sawfly is the giant wood wasp which lays its eggs on dead or

Above: An adult pine beauty moth.

Right: A male Duke of Burgundy butterfly.

Below: A pinewood near Betws-y-Coed, in North Wales.



dying conifers. This large insect, up to 5cm (2in) long, is parasitised by an equally large ichneumon wasp called *Rhyssa persuasoria*. Several gall-forming insects live in the canopy, including adelgid aphids which produce cone-like galls on spruce and cotton wool-like galls on larch.

Conifer colonizers Recent research has shown that coniferous plantations support several nationally rare insects. Some of these are new to Britain and are colonizing us from Continental Europe, whereas others were previously confined to Scotland and are now spreading southwards through England and Wales. Little is known about these insects and it is not yet understood why they favour coniferous woodland, but it is hardly surprising that such vast areas of new woodland habitat prove attractive to some insects.

Some Continental sawfly species are colonizing British conifer plantations, including three species, native to central Europe, which have recently been found in Scotland. Rare hoverflies are also appearing in plantations: *Dasysyrphus friulensis* was first discovered in Britain in 1979 and has been found in several woods; the normal habitat of the rare *Metasyrphus neilsensi* is the Scottish Highlands but it has recently been recorded in some English plantations.

Carpet of needles Mature coniferous forests have very little shrub or herb layer, and the ground layer holds few species. Plant-eating

Left: A male purple emperor basks in the summer sunshine on a leaf of its larval foodplant, sallow. This butterfly is thinly distributed over parts of southern England.

Right: Flying insects, like this drone fly (*Eristalis tenax*), feed on woodland flowers such as the blossom of blackthorn. Such insects help to pollinate these blooms by carrying pollen from flower to flower.

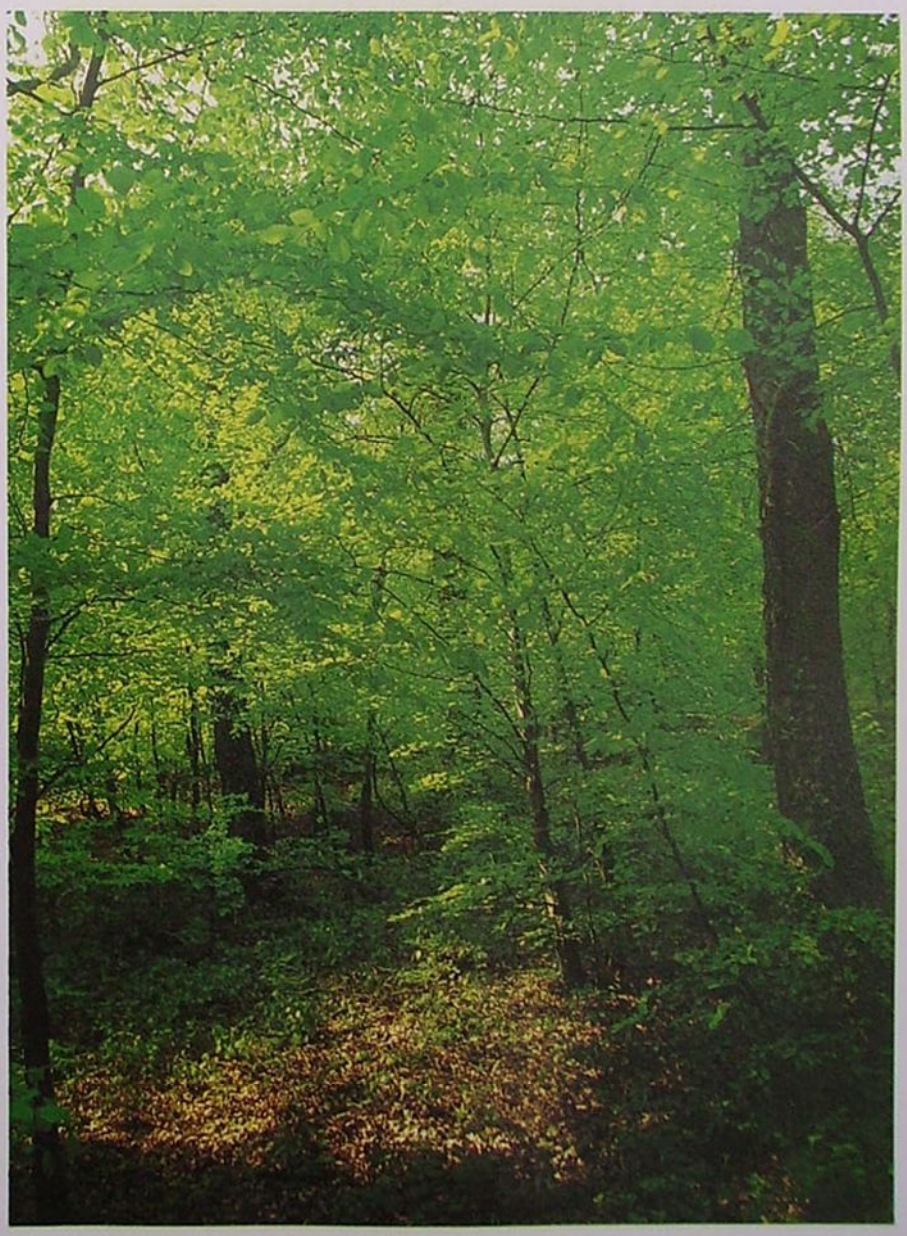
springtails or bristletails are not common in conifer needle litter and consequently there are few predatory species, which rely on these plant-feeders for food. Fungus-eating beetles from the genus *Leiodes* are examples of specialised conifer litter species, feeding on fungi which are the main agents of needle decomposition. A conifer needle may take up to ten years to break down, whereas an oak leaf will be gone in a few months.

Dead wood in coniferous woodland supports many fewer insects than in deciduous woodland, mainly due to the high resin content of such wood, which deters attack. This difference is also reflected in the paucity of life beneath the bark of coniferous trees as opposed to deciduous ones. Caledonian pine forests are particularly valuable because they support several rare insects in dead wood. Here are found such rarities as the beetles *Ostoma ferrugineum* and *Chrysanthia nigricornis*, and the hoverflies *Callicera rufa* and *Blera fallax*, all of which depend upon dead wood for their larval stages.

Young plantations Two special habitats in coniferous woodland which are valuable for insects are the young plantations and wide rides. The best English butterfly woods, with 40 or more species, all have substantial areas of young conifers. These butterflies, including such rarities as the wood white, Duke of Burgundy, and the purple emperor, depend upon wide rides and areas of young trees for larval foodplants and adult nectar sources. However, as the trees develop and shade out the rides and herb layer, these resources are lost. As a result of this process we are at a threshold where, unless open areas are continually created and the rides kept open, the butterflies will decline and become extinct.

There is no doubt that a sharp change from ancient deciduous woodland to coniferous plantation will lead to a fall in the numbers and variety of our native fauna. However, conifer forests will become an accepted part of the British landscape in centuries to come and so we must hope that plantation owners will bear in mind the needs of our native insects in woodland when planning the future of both deciduous and coniferous woods.

Below: The leafy canopy of a deciduous wood and the rich greenery of the shrub layer are good places to find insects. Where light penetrates to the leaf litter bramble, bracken and other species provide food for other woodland insects.



LILIES ON THE WATER

Many water-lilies thrive in Britain, but most are aliens introduced for ornamental purposes; only four species are native to this country.

Above: The petals of the white water-lily are large and numerous; the yellow structures in the centre of the flower are its stamens. Notice the clear vein pattern, with the veins radiating from the centre of leaves (see opposite page), a distinguishing feature of this species.

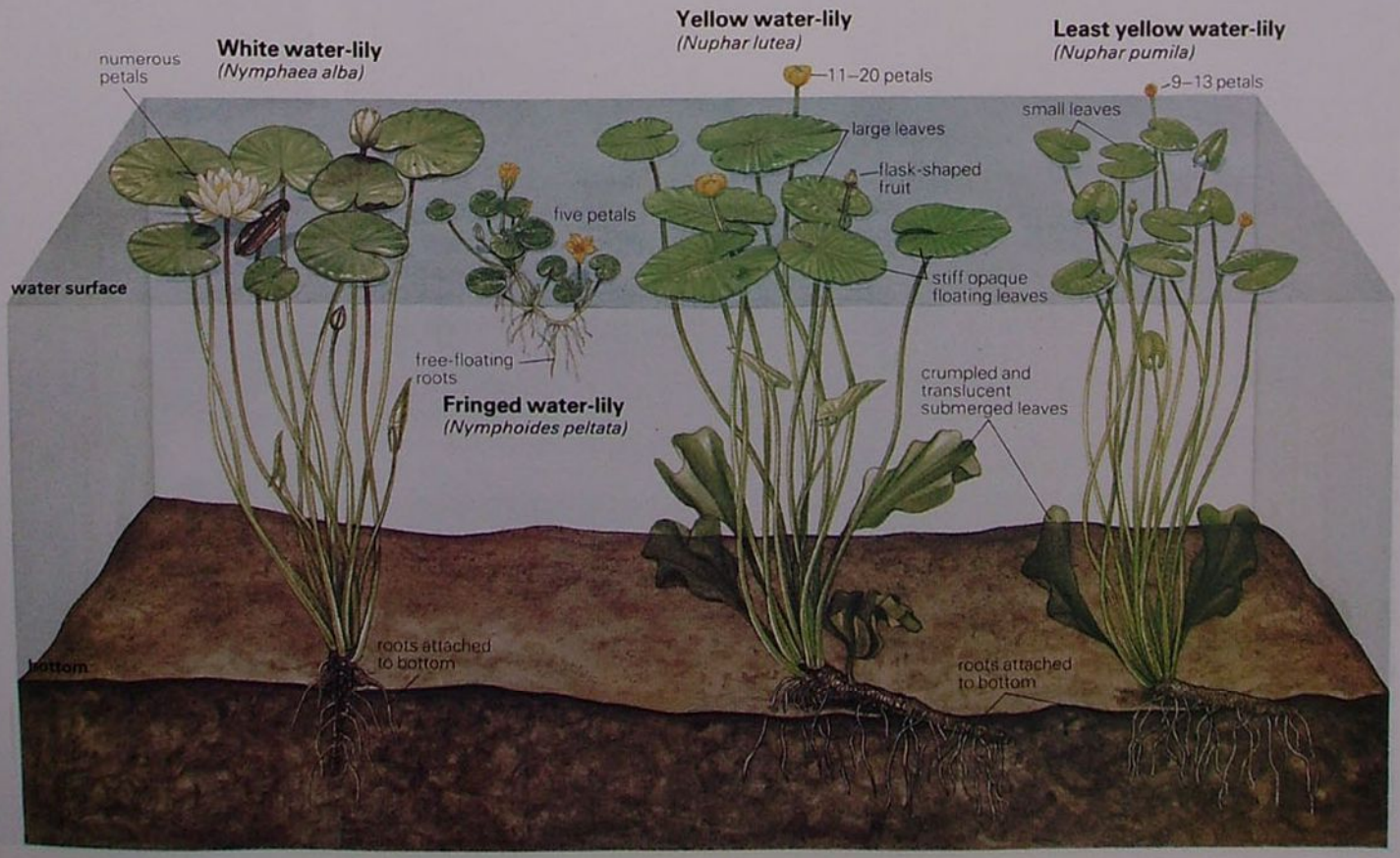
Water-lilies are a characteristic feature of many slow-moving rivers, canals, lakes and ponds, and a wide variety of forms and colours occur. Although only four species are native to Britain, producing either white or yellow flowers, a very large number of alien species and their horticultural cultivars have been introduced to artificial habitats from where they have escaped, adding red, violet and pastel pink water-lilies to the range we already have in the wild.

White water-lilies Of our four native species only one has white flowers–the white water-lily. Forty other species of water-lily with white flowers are native to other parts of the world; these exotic plants are responsible for some of the many cultivated forms so popular today in ornamental pools.

Apart from its white flowers this species can be distinguished by its leaves which are opaque with a waxy upper surface and a distinct vein pattern in which the veins radiate out from near the centre of the leaf.

The white water-lily's size is particularly variable and a small form, often referred to as sub-species *occidentalis*, is common on some

Our four native water-lilies



Left: The fringed water-lily is the rarest of our native water-lilies. Unlike other native species it is free-floating and therefore found only in ditches, ponds, canals and slow rivers, where it is unlikely to be washed away. Features that distinguish this species are its yellow flowers, which have only five petals bordered by delicate fringes, and the slightly wavy outline of its leaves.

Below: The yellow water-lily occurs throughout the British Isles except in northern Scotland and the extreme south-west. The flowers have a curious scent resembling that of alcohol, from which (along with its flask-shaped fruits) the plant derives its other popular name–brandy bottle. Like the least yellow water-lily it has two distinct leaf forms: the submerged leaves are translucent and crumpled while those which float on the surface are smaller, opaque and have stiff, waxy upper surfaces.

lakes in Scotland and Ireland, notably Loughs Cregduff and Craiggamore in Galway and Loch Cally, near Dunkeld. Ireland can also claim to have terrestrial water-lilies: in marshes adjacent to some loughs a small form occurs which can grow for long periods out of water because the plants are covered in moisture carried by the prevailing wet westerly winds.

Although normally considered a lowland plant in Britain, the white water-lily has been recorded on lakes above 300m (1000ft). Angle Tarn in the Lake District ((425m/1400ft high), and lakes high up on Isla in Scotland, and in Donegal, Ireland, all support white water-lilies.

The species requires clear, clean water so it rarely colonizes rivers, preferring the more sheltered bays of lakes. Its dependence on good quality water makes it rarer than the yellow water-lilies–two other native water-lilies–but it is more tolerant than they are of brackish water.

Yellow water-lilies The yellow water-lily and least yellow water-lily belong to the same family (Nymphaeaceae) as the white water-lilies but a different genus. Both species have two distinct leaf forms, the submerged leaves being translucent and crumpled and the floating ones smaller and with a stiff waxy upper surface to repel water and help them float. The phenomenon of different leaf forms is known as heterophylly.

Despite these similarities the two species are generally distinct when not in flower because of their considerable differences in size. The yellow water-lily is much the largest, its rhizome often reaching more than 1m (3ft) long and 15cm (6in) across. The leaves are also large and variable, ranging from 10cm (4in) to 50cm (20in) across. In contrast, the rhizome of the least yellow water-lily reaches only about 3cm ($1\frac{1}{4}$in) across and the leaves rarely exceed 15cm (6in). The least yellow water-lily also has a distinct leaf stalk which is more compressed than that of its larger relative, and has an obvious keel.

When the flowers are in bloom the two

species are very different. The yellow water-lily has much larger flowers with 11 to 20 petals, in contrast to the least yellow water-lily which has between 9 and 13. Both flowers are more fragrant than those of the white water-lily and have a pervading aroma of brandy.

The yellow water-lily is the commonest of our four native species and occurs throughout most of the country except in extreme highland areas where it is replaced by the least yellow water-lily. It is the only water-lily to tolerate poor-quality flowing water and so it is a common member of the plant communities found in lowland rivers flowing over clay. It also grows in lakes with rich organic muds devoid of oxygen; the rhizomes, as well as newly formed submerged leaves, can respire anaerobically (in the absence of oxygen). The least water-lily is confined to the pristine clear highland lakes of Scotland, save for two isolated communities in England and Wales.

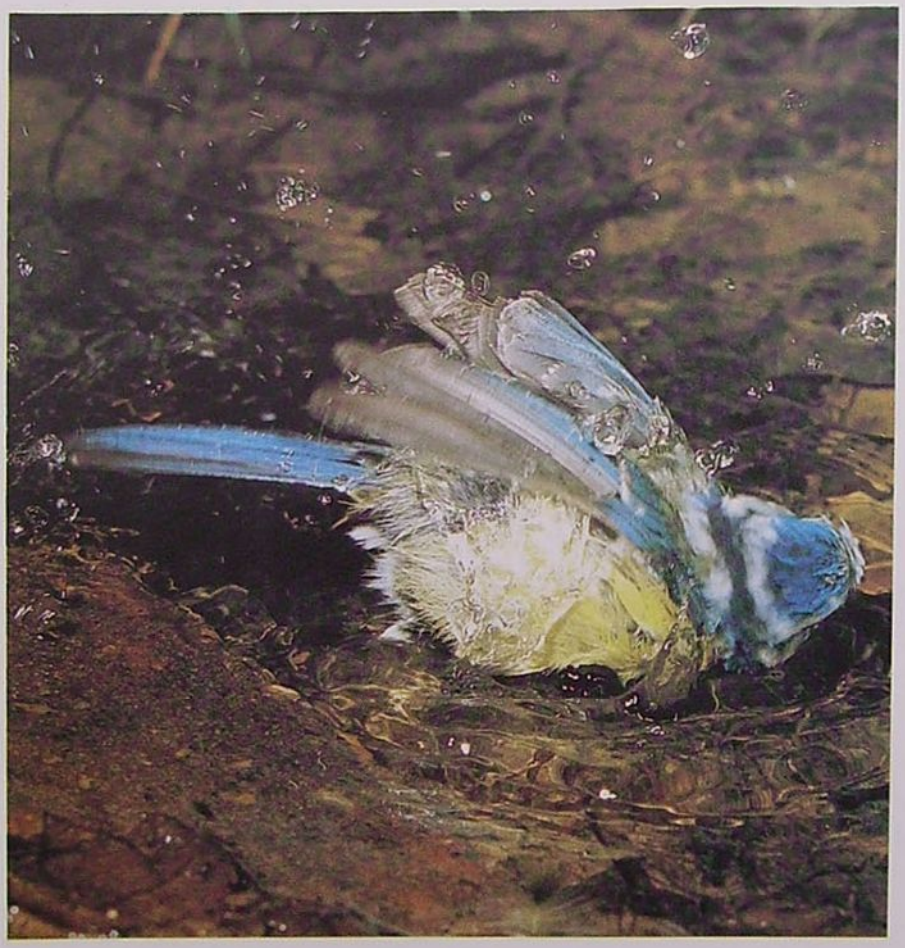
A most interesting hybrid occurs between the yellow water-lily and the least yellow water-lily; its vegetative and floral characteristics are intermediate between the two parents. The hybrid's main stronghold is in southern and central Scotland where both the parents species occur, but it is also found in Northumberland where only one parent grows, the yellow water-lily.

Fringed water-lily The last of our native water-lilies is a beautiful plant belonging to the genus *Nymphoides* in the bogbean family (Menyanthaceae)–the fringed water-lily. Unlike other British water-lilies this species is free-floating (not attached to the mud) and is thus confined to ponds, ditches, canals and sluggish rivers. Its leaves differ from those of other native water-lilies in having a slightly wavy outline and only a few veins which arch from the leaf centre and branch repeatedly. Although usually small, the leaves may occasionally be as large as those of the rooted water-lilies. The flowers also bear no resemblance to other water-lilies since they have only five yellow petals bordered by beautifully delicate fringes. Sadly it is a rare plant, occurring only in central and southern Britain.

Above: The flask-shaped fruits of yellow-flowered water-lilies are unique to these species. They are also important in distinguishing between yellow water-lily and least yellow water-lily. At the top of the fruit lies a flat stigmatic disc which in the former is perfectly etched with 15-20 stigmatic rays that radiate from the centre. Least yellow water-lily, however, has only 8-10 stigmatic rays and a convoluted edge to its stigmatic discs.

BIRDS IN SUMMER: TIMING IT RIGHT

The onset of summer quickens the pace in bird life: foraging becomes a race as young chicks grow, and all bird species suffer heavy mortality too. Each species has its own characteristic schedule of breeding activities, to be completed before autumn.



Above: Spend some time near water if you go birdwatching in summer. Besides water birds, you are bound to see land birds coming to drink and bathe, like this blue tit.

Left: A young wheatear, its plumage still actively growing: the tail feathers are not fully developed. This bird cannot fly very well as yet, but it must become proficient and self-dependant by the end of summer, for its migration to Africa could begin as early as August.

Birds do not waste summer: the season of plenty is short, and throughout it most adult pairs are engaged in a constant struggle to produce young birds for recruitment to their species. The number of recruits that eventually survive to breed is always a small fraction of the number of eggs laid, for birds live hazardous lives, perhaps especially in summer. But whatever the day-to-day risks may be, the overall limiting factor is time, and so the breeding season follows a tight schedule. Autumn will soon bring extra urgency to bird life.

Plants in leaf Summer foliage is exploited as cover for hiding nests by dozens of species that seek to raise their young within trees, bushes or on the ground among grass and other low plants. As May progresses, hedges and thickets become impenetrable, and jays and magpies experience greater and greater difficulty in finding unguarded nests to plunder.

One of the factors that permits this quick growth of new leaves is the increased day length of summer. Throughout May, June and July the sun is above the horizon in Britain and Ireland for over 15 hours a day. Such long days also give plenty of time for birds to forage, both for themselves and for large, growing families.

Arrival of the migrants Plants are the primary producers of food, and the small animals that thrive on their sudden growth produce a rapid peak of protein-rich food at the secondary level–the herbivorous animals. A large amount of this flies in the air in the form of an enormous feast of insects, and it is for these that many species of insectivorous migrant birds visit Britain and Ireland each summer. Warblers, chats, flycatchers, swifts, swallows, martins, nightjars, wagtails and others arrive annually, so by the end of May the total of breeding birds in Britain and Ireland swells to an estimated 120 million. By the end of August, these may have raised enough young to produce a total of over 500 million birds.

Summer mortality It seems at first surprising, but records kept by the British Trust for Ornithology show that for a wide range of species more dead birds are found in summer than in winter. Young birds are obviously vulnerable, but even adults display a peak of mortality spanning the breeding season. Those reporting the discovery of their remains often find evidence of the causes of death: cats, traffic and collision with windows are frequently mentioned. It is intriguing to speculate how much of this loss of life is due to lack of wariness resulting, perhaps, from the distractions of a hectic breeding season.

Having made a nest, parent birds are constrained to return to it at regular intervals, easily attracting the attention of cats and certainly, if a road lies *en route*, increasing the risk of being hit by traffic. Many summer visiting birds die in this country, though we know little of the severity of dangers that face

such birds on migration or in their winter quarters.

As for the fledglings, many die within a month. Their instinct for danger is not yet reinforced by practical experience, their flight is often weak, and they must call to their parents to demand food at regular intervals: surely an invitation to disaster if cats or other predators are common.

When to see birds breeding For the bird-watcher who takes an interest in breeding behaviour, it is fascinating to observe the great variety in the schedules followed by the different species.

Among the earliest breeders are the ground-feeding birds, such as the song thrush and the blackbird. Taken as a group, the ground-feeders are not particularly selective in the foods they eat, though animals are generally predominant in summer rather than seeds, nuts or fruits. They take worms, slugs, millipedes and any other similar animal they find in the soil. This kind of food is less seasonal than most; good quantities are available in milder phases of winter, and certainly as soon as March begins there is sufficient for some blackbirds to start laying eggs.

Apart from the problems large ground-feeders such as rooks experience if dry weather in July hardens the earth into an impenetrable crust, the soil and its surface continue to provide nourishing small animals all through the summer. Both blackbirds and song thrushes are able to continue their breeding over a long season, and may raise three or even four broods, the last becoming independent in September.

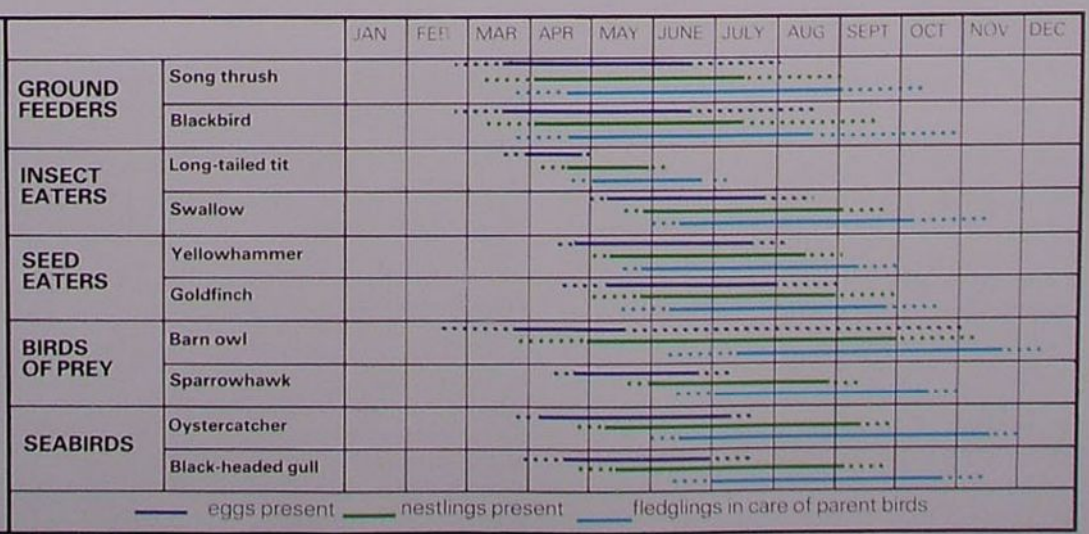
Insect-eaters do not start their season quite as early as the song thrush and blackbird, waiting at least until late April. May is generally the time when the winter moth

Above: The hobby is an insect-eating raptor, but it also takes swallows, martins and swifts, particularly as food for its young. The best time for it to raise chicks is July and August, when young victims are plentiful.

Below: A guide to the breeding activities you can expect to see in ten sample species as summer progresses. A dotted line shows where an activity may be taking place in only part of the British and Irish population of the species. It reflects north-south variation and other differences. Because of the problems of observation, the time spent in parental care is an estimate.

Timing the clutch

Different birds breed according to different schedules. The first six birds here represent small species: ground-feeders breed earliest, followed by insectivores (except migrants like the swallow) and then seed-eaters. Among birds of prey, two contrasting strategies are shown: the flexible timing of the barn owl and the fixed timing of the sparrowhawk. To complete the picture, two seabirds are shown.



caterpillars hatch in their millions, and blue tits and other members of the tit family choose to mate at the precise time when their ensuing single brood of young will develop in time to thrive on these caterpillars.

The breeding season of swallows, swifts and martins is determined both by the time these migrants arrive in this country and by their dependence on flying insects. Their first eggs are laid from mid or late May onwards.

Of resident birds, the seed-eaters are generally the latest breeders, for seeds do not become abundant until late May. The first broods of finches and buntings can be expected to be on the wing from this time onwards, feeding from each plant species in turn as the seeds ripen.

Birds of prey Among the larger birds are those that feed by swooping down upon other birds or on terrestrial animals: the predators. Within this diverse group, timing strategies of breeding vary. Barn owls feed on many different kinds of prey, from mice and birds to earthworms and large insects. They can take whatever is available at the time, and this enables them to be flexible in the timing of their breeding. Though pairs raise only one brood, they can choose to lay their clutch of eggs in almost any month of the year. Most are incubating in April and May, the young taking wing some ten weeks later.

This does not apply to all predatory birds, however. The sparrowhawk feeds almost entirely on birds, often specialising on particular species. Thus males (the smaller sex) frequently catch finches, sparrows, buntings or tits, while the female hunts thrushes and starlings. Like barn owls, the sparrowhawks are single-brooded, but their breeding season must synchronise with the peak availability of young, easily caught victims. Their young are in the nest from mid May to July or August.

Precocious young The chicks of most waders and gulls are relatively mature when they hatch–able to see and run about when only hours old. This does not shorten their breeding season: incubation and fledging times of three to four weeks and five to six weeks respectively are typical.

Above: The ptarmigan lives in the Highlands and north of Scotland, where the snow lies late into the year. Its breeding season has to be a late one: the chicks come only after the snow has melted.

Below: This puffin chick has been lifted out of its burrow for photographing (if done with proper care, this will not harm it). The chick is fed by both parents throughout June and into July, when it emerges to fend for itself.

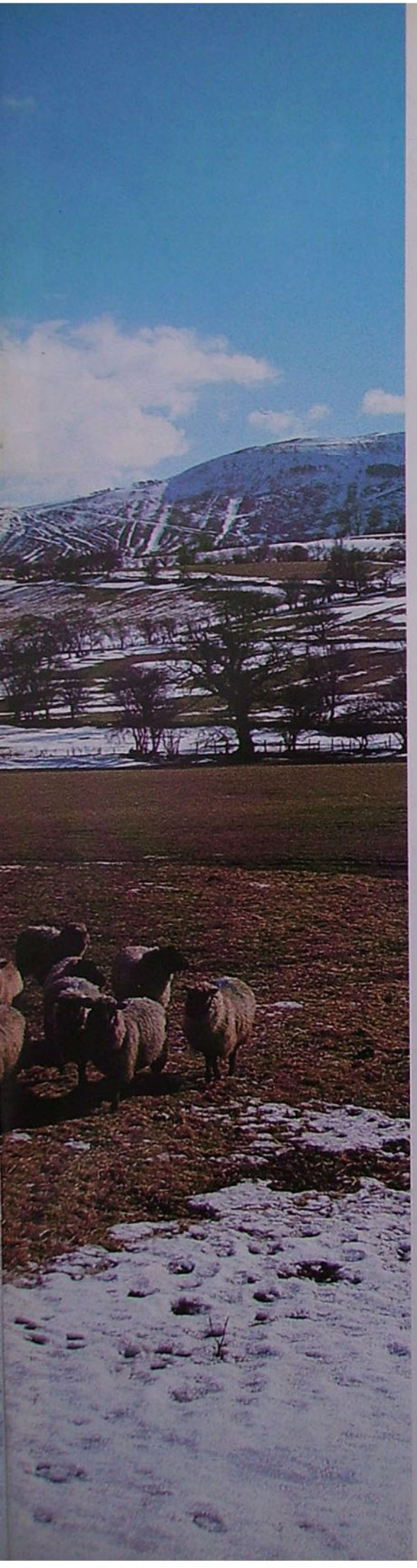
FARMING IN THE BRITISH UPLANDS

Discouraged by economic policies favouring high production rates, many of today's farmers in the mountain and moorland areas of the British Isles have abandoned the traditional rough husbandry which formerly maintained the wild and exceptionally beautiful character of the hillsides.

Above: Upland farms consist of a small area of rich valley land and a broad expanse of rough pasture (low-grade permanent grass, heather moor, peat bog, scree slopes and bare rock). Such land is not suitable for arable crops or high-yielding dairy cattle. The only agricultural use to which it can sensibly be put is grazing hardy sheep or beef cattle, like this Highland calf (below), at low stocking densities.

In 1902 the geographer Sir Halford Mackinder proposed a simple division of the British Isles into highland and lowland zones, roughly defined by a line drawn on the map from the mouth of the Tees at Middlesbrough to the mouth of the Exe in Devon. To the south and east the landscape is characterised by gentle, rounded hills and broad plains, underlain by soft sedimentary rocks which have weathered into fertile soils under the influence of a mild climate. The land is intensively farmed and densely populated.

To the north and west of the Tees-Exe line the character of the landscape is determined by a geology of resistant rocks forming upland ranges, cut by narrow valleys eroded by streams and gouged out by glacier ice. Here the climate is harsh, and most soil is poor.



Hill farming Traditionally hill farming is restricted to the rearing of hardy sheep and beef cattle. The area of valley land on the average hill farm is comparatively small, and the farmer needs it all to grow enough forage crops to maintain the animals through the cold months and meet the extra demand caused by lambing and calving in the spring. During the summer the sheep and cattle are grazed on the natural vegetation of the hills where they find enough for maintenance and milk production (to feed their lambs and calves), but certainly insufficient to achieve the growth rates desirable in animals reared for meat.

Traditionally, therefore, much of the hill farmer's income is derived from young animals sold on to better land for 'finishing' to a good weight. Known as store cattle and store lambs, they respond well to improved conditions after an early life on the hills, and can make a handsome profit for the purchaser.

The other main product of the hill farm is the draft ewe. This is a breeding female sheep which has spent two or three years on the hills, and is unlikely to manage another season without loss of condition. 'Drafted' from the hills and sold into better conditions she can manage another two or three lambing seasons, and may be mated to a lowland ram to produce the very efficient hybrid ewes which form the basis of commercial fat lamb production.

Selling stores and draft ewes is not a particularly lucrative business. Such animals are the raw material of farming, not the finished product, and the prices they fetch at the sales are often low and always unpredictable. For the enterprise to be viable, therefore, the farmer must cut costs to a minimum or

Opposite page: The Brecon Beacons in winter. The climate in the upland areas of the British Isles is harsh; the rainfall is high and the evaporation rate is slow. Consequently there is a constant downward flow of water through the thin soils, down the steep slopes and into the valleys. The water carries with it the nutrients leached out of the upland soils, and indeed much of the soil itself, dumping both on the valley floors to form ribbons of fertile land.

Below: Scottish blackface sheep in a spring blizzard. The exposed uplands of the British Isles are remarkable for their beauty, scientific value and historic interest. It is a tragic irony that the subsidies farmers receive which, officially, were intended to conserve the landscape and maintain the upland way of life have in many cases been employed to do exactly the reverse. Opponents of agricultural subsidies would say this was inevitable; yet without support hill farming communities and their environment would probably have been destroyed long ago.

find another source of income.

Counting the cost Cutting costs is difficult, simply because hill farming is, and always has been, a very low-input activity. Most of the land is of low agricultural value, and the animals feed mainly on wild, self-sown vegetation: the herds and flocks are largely self-regenerating, and they are normally wintered in the field, requiring no special housing. The small area of cultivated land demands little in the way of tillage equipment: recent trials have suggested that under such conditions horses may be more efficient than the tractor. The capital equipment of some hill farmers amounts to little more than a shepherd's crook and a couple of sheepdogs.

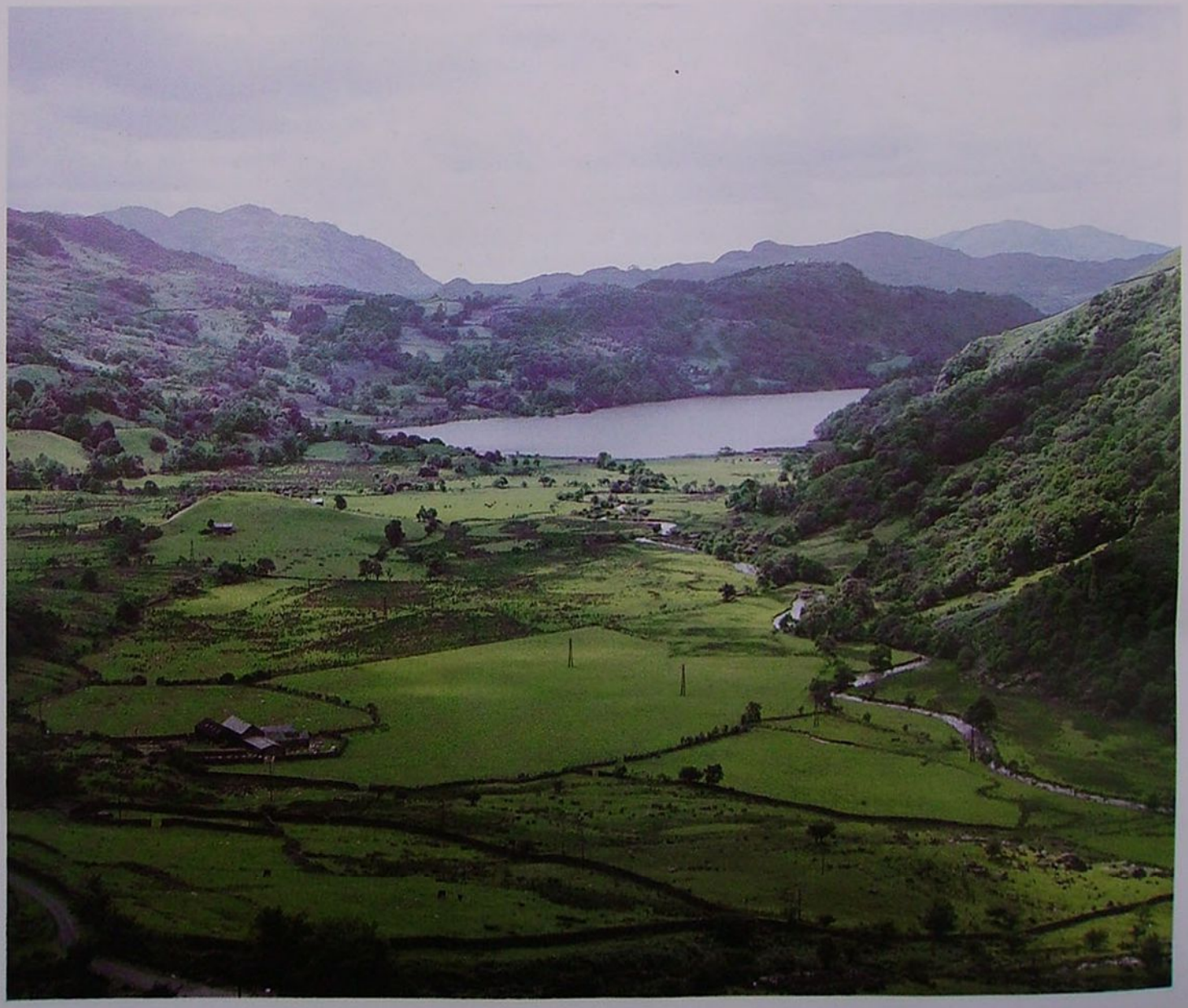
With costs already at a minimum, the hill farmer in search of improved profit margins must look for another income. In the past this was provided by supplementary occupations: quarrying, mining, weaving or estate work. Farming was regarded as a part-time activity for a large family; there was always someone on hand to look after the interests of the animals–they were, in any case, largely self-sufficient.

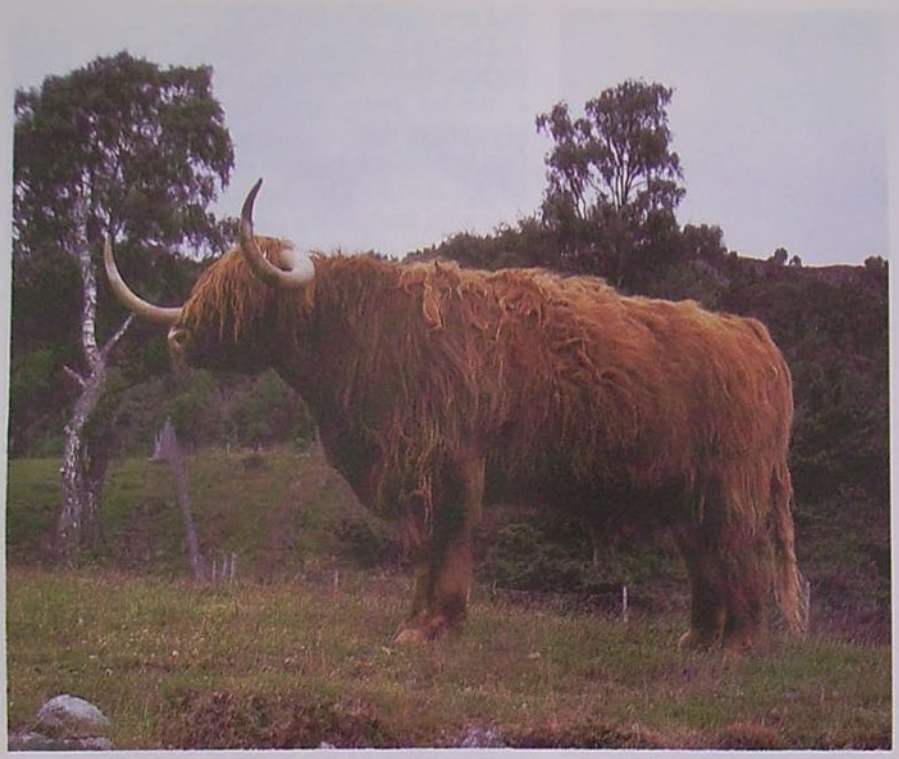
By the end of the 19th century, however, a decline in local industry was beginning to throw the hill farmers back on their own resources. Finding it impossible to make an adequate living from farming alone, many gave up altogether and moved out. From being an advantage, a large family became a liability on a farm which could barely support the parents, even in a good year. By the middle of the 20th century it had become apparent that the future of hill farming could only be assured by some form of subsidy.

Subsidies In 1945 the British Government was anxious to maximise food production. In the hills this encouragement took the form of substantial capital grants and 'headage' payments on beef cattle and sheep. Originally intended to give farmers a safety net in a bad year, the payments soon became an indispensible supplement to their annual income.

When Britain joined the EEC in 1972 this system was retained but the official object of the policy was changed. From being a purely

Below: Nant Gwynant, Gwynedd. The boundary between the rough hill grazings and the fertile land on a typical upland farm is very marked, and often forms a continuous line running right up to the head of each valley. Above the line the vegetation is a random mosaic of wild grasses, heather and bracken, often unenclosed. Below the line the richer land is divided into fields of improved grass or forage crops, grown to provide hay, silage or grazing for the livestock brought down off the mountain during winter. The pattern of settlement is discontinuous, with the population concentrated in the sheltered, fertile valleys, each isolated from its neighbours by impoverished, bleak and windswept highlands.





Above: A Highland bull and (below) a shepherd and his dog in the Borders Region. The capital equipment of some hill farmers is little more than a crook and a couple of sheepdogs: hence the term 'dog and stick farmer' employed somewhat contemptuously by the high-input lowland arable man. While the more prosperous upland farmers have drawn inspiration from the hill subsidies, the dog and stick traditionalists have continued their steady decline.

agricultural subsidy, designed to maintain farm incomes and production, the system was adopted as a response to the EEC directive of Less Favoured Areas (LFA): a measure aimed not at production, but at conservation.

The idea of the LFA directive is that, by giving support to small farmers in upland regions, traditional agricultural methods remain viable, and the landscape with its associated wildlife is conserved. Depopulation is arrested, services are maintained, and the cultural identity of each region is preserved. In Europe this policy has been applied with some success, much to the irritation of many British taxpayers who complain about subsidising inefficient peasant farmers.

In Britain the social and environmental aims of the LFA have been neglected by the Ministry of Agriculture, Fisheries and Food, which has remained preoccupied with maximising production. This would not matter, perhaps, except that the area covered by the support policy includes not only hill farms on poor land, but also 'upland' farms consisting entirely of improved pasture and arable land. Here of course the potential for production is higher. At the other end of the scale, small farms which do not clearly constitute a full-time occupation for the farmer are ineligible for some of the grants and subsidies. In actual fact many of these 'part-time' enterprises represent the total income of the farmer involved.

The result of this is that the larger and more efficient upland farmers have received a disproportionate share of the financial support which should, according to the LFA directive, be supporting the relatively inefficient traditional hill farmer. The environmental and social consequences have been profound. In the mountain and moorland areas small farmers have continued to go out of business despite the subsidies, while their counterparts in the richer uplands have been able to undertake extensive cut-price reclamation and improvement schemes, so enabling their farms to become more productive, yet still officially remaining part of the 'less favoured areas'.

With the aid of grants, the big upland farmers have taken the plough into the roughlands, and although the actual costs often exceed the real benefits, the grant aid and high guaranteed prices for the produce mean that such ventures can be made to show handsome profits. It is the landscape and wildlife of the hills which bear the loss.

DOVES OF THE FAR NORTH-WEST

Out on the rocky northern and western fringes of the British Isles dwells the rock dove—the remotest and the least known of our native pigeons.

Above: The rock dove—wild relative of the town pigeon.

Rock dove (*Columba livia*). Resident in rocky habitats. Sexes alike. Length 33cm (13in).

Below: The rock dove's cave nest—spartan but safe.

The rock dove was formerly a more widely distributed bird round the coasts of Britain than it is at present, and its main strongholds are now the north and west of our islands, where it still occurs in considerable numbers. Because of this restricted distribution, the rock dove is the least familiar of our native pigeons. Not only does it live in wild and beautiful places, but the bird itself is an attractive species that merits a closer look than the cursory glance we usually give to pigeons in general, familiar as they are to us in both town and country. At first sight, there may even seem to be little to distinguish it readily from many of the familiar street pigeons of our towns and cities; in fact, the two are closely related.

The rock dove is smaller than a wood pigeon, about the size of a stock dove and with a similar basic grey colouring. The most prominent distinguishing characteristics are two bold black bars on each wing and a clear white rump. The breast lacks the wine-coloured flush of the stock dove but the upper breast and sides of the head have a brilliant metallic purple and green sheen which is very striking when seen at close quarters.

World-wide spread Pigeons are a successful family of birds and occur in one form or another the world over. The rock dove itself has a wide distribution which extends from the Atlantic seaboard eastwards across southern Europe and North Africa to central Asia where it is replaced by the paler eastern form of the same species. Rock doves are basically birds of rocky areas where there are nearby open spaces on which they can feed. Such areas are provided by the coastal zones of the Atlantic seaboard of Britain, where the birds come to the clifftop fields or to inland cultivated patches to feed, and retreat at night to the safety of sea caves.

Declining species Speculation suggests that the rock dove is native only to warm temperate and sub-tropical zones, and thus more a Mediterranean than a British species. The species may have spread northwards in the wake of agricultural man before historical times. Whatever its origins, the British population of rock doves has decreased greatly during the present century. The species has been entirely lost as a breeding bird in the coastal areas of England and Wales, where it was once common in counties such as Devon, Cornwall, Yorkshire and Northumberland as well as the rocky headlands of west Wales. The reasons for this decline are obscure. Although birds exhibiting the diagnostic double wing bar and white rump can still be

encountered on some English and Welsh coasts, they are almost certainly not pure rock doves but only 'throwbacks' from hybrid stock renaturalised in the wild.

Seeds and small animals Like our other native pigeons–wood pigeons, stock doves, turtle doves and collared doves–the rock dove is a ground feeder, largely eating grains and wild seeds. It seeks these on ploughed land, fallows and stubbles. The British birds differ from the Mediterranean rock doves in being forced by their harsher littoral environment to accept a more wide-ranging diet. This includes foraging among tide wrack, marram dunes and piles of seaweed for insects, seeds and even small molluscs, and it is not uncommon to disturb parties of rock doves feeding in this way on beaches.

Cave and rock nesters Rock doves' lives are closely bound up with caves and rock crevices, and they both roost and breed on ledges in such places. They never perch on trees or bushes, or associate with them in any way–they are the only species among our resident pigeons not to do so. Often the caves in which they live round the British coasts are dark, and damp with sea spray, but they live securely in them, laying two eggs which are placed on a token nest of heather twigs or grasses on bare ledges.

A number of pigeon species have protracted breeding seasons, and the rock dove certainly comes into this category, with eggs likely to be found in any month of the year–but with a peak which occurs between April and July. Whole groups of birds appear to breed simultaneously, which means that periods of breeding are often followed by short intervals of quiescence before a further series of clutches is laid.

Birds for the table Apart from the natural history of the rock dove in its own right, there is an equally important 'unnatural history' of its association with man and its consequent evolution thereby into a series of distinctly separate forms. The association with man owes something to the rock dove's ledge-nesting habits, to its excellent palatability and to its inclination to nest all round the year. Probably the very first steps were taken by the bird itself, in adapting its nesting habit and breeding on the ledges of buildings as well as in caves. This gave man an easy means of taking squabs (young pigeons) as food, and it was thereafter but a short step to domestication.

An example of early domestication is Culver Hole, situated on the cliffs of the Gower peninsula in South Wales. This is a remarkable relic from the 13th or 14th century, known as a columbarium. Culver Hole is a narrow cave, 18m (60ft) above the sea, that was once walled up and provided with numerous man-made ledges on which the rock doves nested and the chicks could be harvested easily. The columbarium was a forerunner to the thousands of dovecots in the British Isles. Dovecots were built for domesticated stocks of rock doves and were provided with plenty of nest ledges: their owners supplied ample grain in return for an unending supply of squabs for the table.

The feral pigeon appears Other uses for these domesticated pigeons followed in succeeding centuries, notably the modern vogue for pigeon racing. All the myriad town pigeons and mongrel 'rock dove' populations occurring on inland and coastal cliffs in southern Britain derive from rock dove stock. Nowadays these feral pigeons inhabit even the heart of our cities, breeding on building ledges and under bridge arches which simulate the cavern ledges of their ancestors, and feeding in the streets and parks on the spillings and surpluses of urban man. Many are identical in appearance to rock doves.

Rock doves

These are rock doves as seen in the wild, but many feral pigeons are seen in towns, looking identical to rock doves.

Left: Rackwick cliffs on the island of Hoy, Orkney. Such cliffs are typical habitats of the rock dove. Birds nesting on tuftless stacks or small, rocky crags have to make daily journeys to larger islands to find sufficient food. It is even postulated that the rock doves on the remote islands of St Kilda cross 70km (45 miles) of sea to the Hebrides each day at times of year when food is scarce. This behaviour lends itself to adaptation in domesticated racing pigeons.

CRICKETS AND GRASS HOPPERS

Above: The common field grasshopper can be recognised by the hairy under-surface of its thorax, a feature clearly shown in this picture.

Right: Ground hoppers are told by their long, hard pronotum–the shield-like plate behind the head. To find this common ground hopper you need to look in mossy areas with plenty of bare ground. It is active by day but does not sing and is easily overlooked.

Below: The large marsh grasshopper is clearly recognisable from its yellow body, marked with black, and its yellow, black and pink legs. It lives in marshes and bogs of southern England and parts of Ireland.

Though they live in different habitats and lead different lives grasshoppers and crickets are all too easily confused, even by experts.

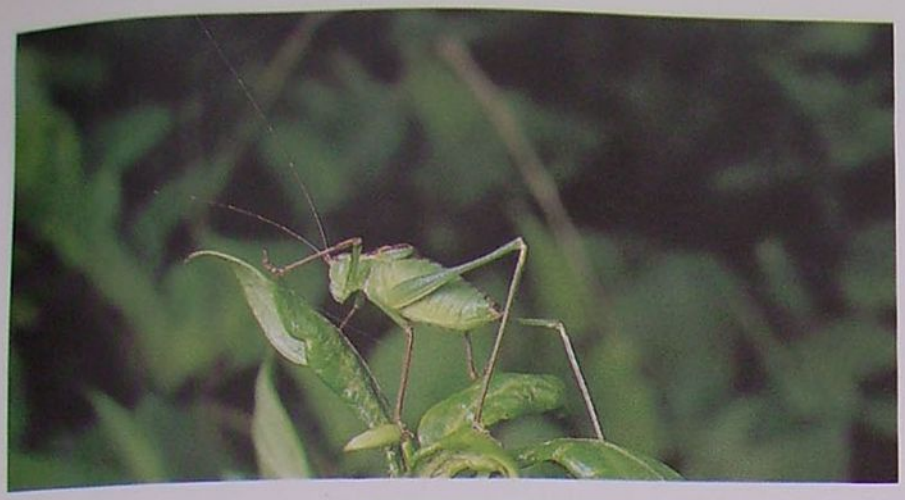
The grasshoppers and crickets belong to the same group of insects, although there are important differences between them in both structure and behaviour. These insects all belong to the order Orthoptera, a name which means straight-winged and refers to the relatively narrow forewings which lie neatly along the sides of the body at rest. The hindwings are much broader and more delicate, but many grasshoppers and crickets have lost their hindwings and are therefore flightless. All have biting jaws and a saddle-shaped shield called the pronotum just behind the head. The shape of this shield is of great value in classifying and identifying the grasshopper. The hindlegs are enlarged for jumping.

Although several hundred species are found on the Continent only 30 occur in Britain–not all of these being native–and only 11 have been recorded from Scotland. The British species fall into five major groups: grasshoppers, ground hoppers, bush-crickets, true crickets and mole-crickets.

Grasshoppers These insects have short antennae and feed almost entirely on grass and other low-growing plants. They sing by rubbing their hindlegs against their forewings. All but one of our 11 species have a row of minute pegs on the inside of the hind femur, and these pegs produce the sounds as they strike a prominent vein on the wing. The exception is the large marsh grasshopper (*Stethophyma grossum*), which has the pegs on its wings instead. However, this large grasshopper rarely sings or stridulates in the normal way: the male's usual call is a ticking sound produced by flicking the hind tibiae against the wing-tips.

Apart from the meadow grasshopper (*Chorthippus parallelus*), all our grasshoppers are fully winged and fly well. The meadow grasshopper has vestigial hindwings, and the forewings are also shorter than normal, especially in the female. Our other species are all similar and identification is made more difficult by the great colour variations within a species. The songs are often the best guides to the identity of grasshoppers.

There are, nevertheless, a number of visual clues which help to separate the species. Members of the genus *Chorthippus* all have a small bulge on the front edge of the forewing, quite close to the body. Within this genus the lesser marsh grasshopper (*C. albomarginatus*) –which is found on very dry pasture as well as



Above: A male speckled bush-cricket sitting on a bush. These crickets are found well off the ground in bushes and bramble patches where their mottled green coat makes them hard to find. Adults of this species differ in that the males have very short wings used only for singing, while the females have tiny vestigial wings. The female is also distinguished by her large ovipositor.

Right: Wood crickets are now rarely found outside the New Forest, where the bubbling song of the male can be heard by day and night. The female (shown here) is easily told apart by her pointed ovipositor and fat body. The wood cricket is unusual in that the time from egg to adult is two years–most other species take only one year.

Below: Rufous grasshoppers are found on sunny slopes on chalk downland. This male shows the characteristic white-tipped club antennae which help to identify this species in the field.

clear white stripe on the wing. The common green grasshopper (*Omocestus viridulus*) is superficially similar, but lacks the parallel veins. Its close relative the woodland grasshopper (*O. rufipes*), again confined to the south, is darker and has very clear white palps on the face. The underside and tip of the abdomen is bright red or orange when mature.

Ground hoppers The common ground hopper (*Tetrix undulata*) is one of three species in this group native to Britain. It can be distinguished from the other two by its hindwings not reaching the tip of the pronotum. The other two species, confined to southern counties, inhabit moister places and both swim very well. Their hindwings reach at least as far as the tip of the pronotum.

damp grassland–can be recognised by the parallel keels along the top of the pronotum, while the common field grasshopper (*C. brunneus*) has a very hairy underside.

The rufous grasshopper (*Gomphocerippus rufus*) also has a bulge on the forewing, but can be readily distinguished by its white-tipped, clubbed antennae. Our only other grasshopper with clubbed antennae is the mottled grasshopper (*Myrmeleotettix maculatus*), a smaller species found mainly on dry grassland and heaths. The stripe-winged grasshopper (*Stenobothrus lineatus*), confined to southern localities, has an enlarged central area of the forewing distinctly marked with parallel veins. It is mainly green, often with a

Bush-crickets These are often confused with grasshoppers, but their antennae are very much longer–often much longer than the body; females are easily recognised by the broad, sabre-like ovipositor. Unlike the grass-inhabiting grasshoppers, the bush-crickets are partly or entirely carnivorous, eating a variety of other insects. Preferring taller vegetation to that used by the grasshoppers, they are often active by day but tend to wake up more towards evening: some species sing all night. The song is produced by rubbing the wing bases together, and for this reason the male forewings look quite different from those of the female. Only five of our ten species can fly, with the wings being greatly reduced in the others, especially in the females: the males always retain enough of the forewings to be able to sing. The songs tend to be of a higher pitch than those of the grasshoppers and they often last much longer. Bush-crickets, like true crickets, have their ears on their front legs, right at the top of the tibia: grasshopper ears are on the abdomen.

Largest of our bush-crickets is the great green bush-cricket (*Tettigonia viridissima*), which is confined to southern areas and found mostly near the coast. Commonest is the flightless dark bush-cricket (*Philodoptera griseoaptera*), whose staccato chirp pours out from bushes and hedgerows throughout southern England in summer and autumn.

GROUP	SPECIES	DISTRIBUTION									HABITAT								STATUS
		SCOTLAND	NORTHERN ENGLAND	MIDLANDS	NORTH WALES	EASTERN ENGLAND	SOUTH WALES	SOUTHERN ENGLAND	IRELAND	SALTMARSH	WET HEATH	MOIST GRASSLAND	CHALK	DRY GRASSLAND	COASTAL	SCRUB	WOODLAND	
Bush-crickets	OAK			●	●	●	●	●								●	●	Common
	GREAT GREEN					●	●	●							●	●	●	Common
	BOG		●	●	●	●	●	●			●							Locally common
	ROESEL'S				●	●		●	●	●		●			●			Rare
	SHORT-WINGED CONE-HEAD				●	●	●	●		●		●			●			Locally common
	LONG-WINGED CONE-HEAD							●		●		●			●			Rare
	SPECKLED	●		●	●	●	●	●	●							●	●	Common
	DARK			●	●	●	●	●								●	●	Abundant
	GREY						●	●						●	●	●		Locally common
True crickets	WOOD							●									●	Locally common
Grasshoppers	LARGE MARSH					●		●	●		●				●			Locally common
	RUFOUS							●					●					Locally common
	STRIPE-WINGED					●		●					●					Uncommon
	COMMON GREEN	●	●	●	●	●	●	●	●			●		●				Abundant
	WOODLAND			●			●	●									●	Common
	COMMON FIELD	●	●	●	●	●	●	●	●				●	●				Abundant
	MEADOW	●	●	●	●	●	●	●			●	●	●	●				Abundant
	LESSER MARSH			●		●	●	●	●			●			●			Locally common
	MOTTLED	●	●	●	●	●	●	●	●				●	●				Common
Ground hoppers	COMMON	●	●	●	●	●	●	●	●				●	●			●	Common
	SLENDER			●		●	●	●	●		●				●			Locally common
	CEPERO'S						●	●			●				●			Uncommon

The insect is difficult to spot, however, for it often moves to the other side of a leaf or stem when disturbed. The speckled bush-cricket (*Leptophyes punctatissima*), is another very common species in the south, where it inhabits brambles and nettle beds. The last two are the only bush-crickets to have been found in Scotland.

Perhaps the most often seen bush-cricket is the pale green, oak bush-cricket (*Meconema thalassinum*), a fully winged species which is commonly attracted to house and street lights in autumn. It lives in a variety of trees and is very common in garden apple trees.

Below: The great green bush-cricket is quite common along the coast of south and south-west England. This large bush-cricket is usually heard more often than seen; the males produce an incessant shrill song which travels up to 200m (600ft) on a clear night.

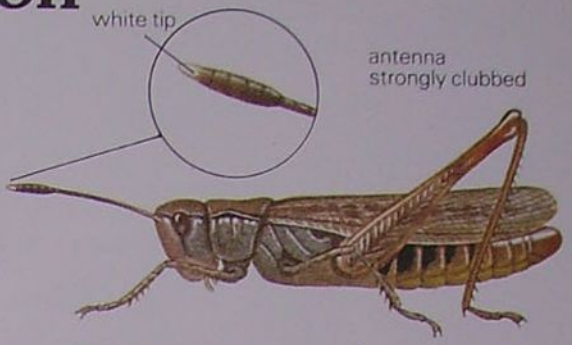
True crickets These are distinguished from bush-crickets by being more flattened from top to bottom and by the females having a needle-like ovipositor. The feet have three segments, as opposed to four in the bush-crickets. The males of the two families sing in a similar way, but the right forewing overlies the left in the true crickets–the opposite of the bush-cricket condition. Our only common species is the introduced house cricket (*Acheta domesticus*), an omnivorous insect found on rubbish dumps and in heated buildings such as bakeries. It flies well and has a shrill chirp, produced mainly at night. The field cricket (*Gryllus campestris*) is now a very rare insect, confined to a few grasslands close to the south coast. Overwintering as a nymph, it is adult in April and sings in the sunshine at the mouth of its burrow. The wood cricket (*Nemobius sylvestris*) is also confined to southern areas. Neither the field cricket nor the wood cricket can fly. Both species are largely vegetarian.

Mole-crickets This group is represented by just one species in Britain–*Gryllotalpa gryllotalpa*. Now a very rare insect, it is easily recognised by its enormous front legs, with which it tunnels in the ground. It eats roots and a variety of small animals. Found mainly in moist habitats, it sometimes flies on warm evenings. The male produces a churring song at the mouth of his burrow, stridulating in the same way as the true crickets. The female lays her 200-300 eggs in a mass in an underground nest and guards them against predators until they hatch a few weeks later.

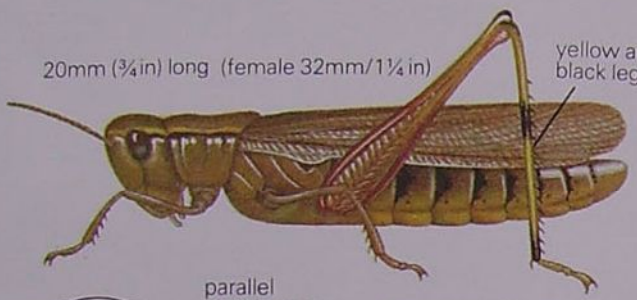
Grasshopper identification

Grasshoppers are often difficult to identify, as they are all similar in shape and size. The usual way of identifying insects, using colour, is of no use with grasshoppers because they are so variable, ranging from grey through to green or brown; for example the common field and mottled grasshoppers have at least 12 distinct colour forms.

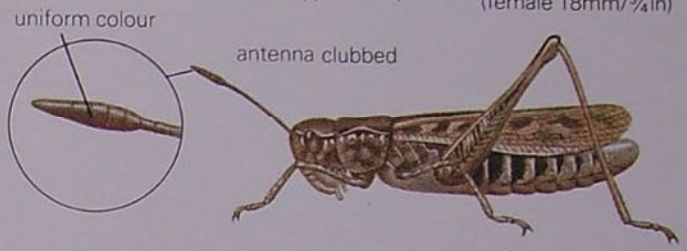
To identify an adult grasshopper in the field, use a small magnifying glass and look at the features highlighted below—in particular the outline of the wing edge and shape of the antennae. Note also the habitat in which you find the grasshopper, for some species are only found in the places shown in the chart, opposite left.



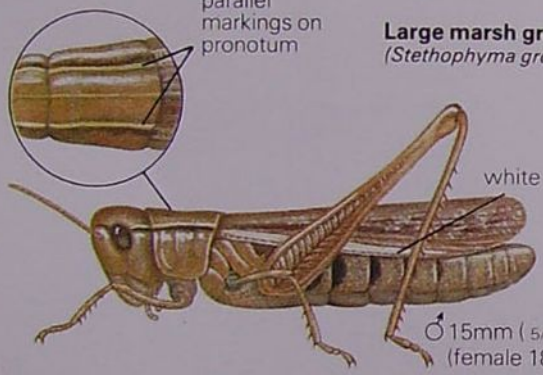
Rufous grasshopper
(Gomphocerippus rufus)
♂16mm (5/8in) long
(female 18mm/¾in)



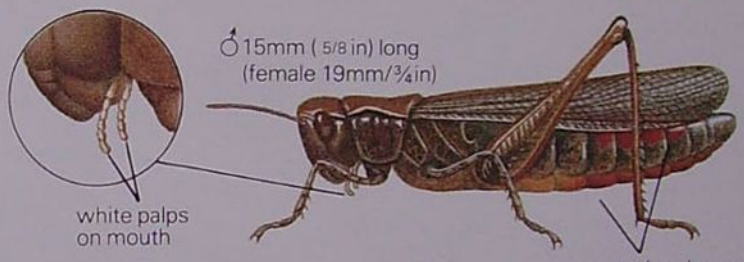
Large marsh grasshopper
(Stethophyma grossum)



Mottled grasshopper
(Myrmeleotettix maculatus)
♂13mm (½in) long
(female 15mm/5/8in)

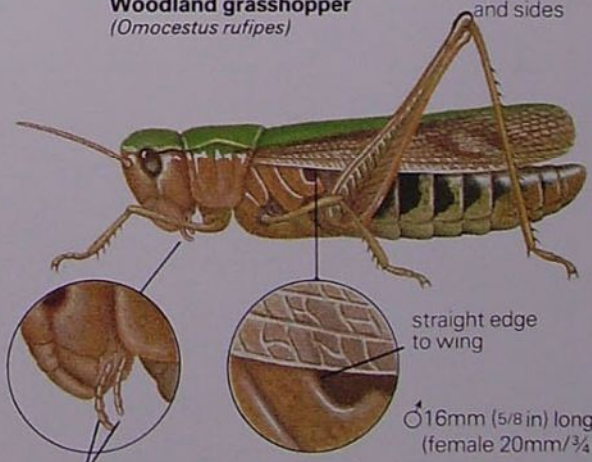


Lesser marsh grasshopper
(Chorthippus albomarginatus)

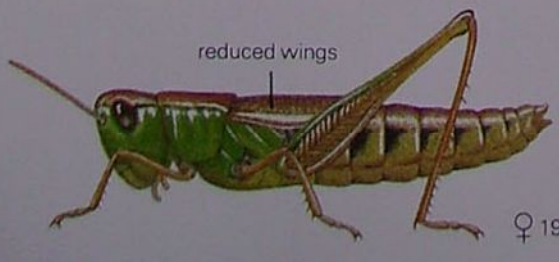


Woodland grasshopper
(Omocestus rufipes)
red underneath
and sides

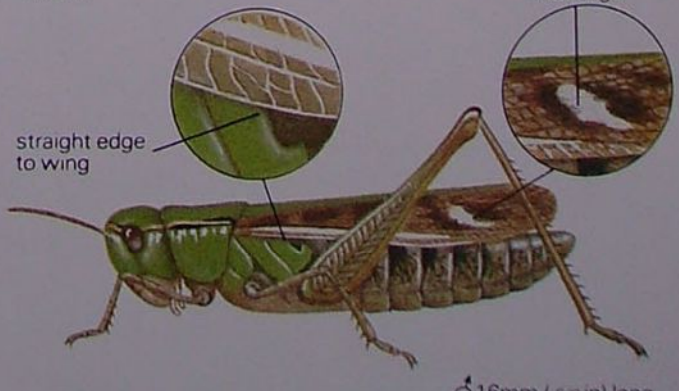
Common field grasshopper
(Chorthippus brunneus)
♂17mm (¾in) long
(female 22mm/7/8 in)



Common green grasshopper
(Omocestus viridulus)
♂16mm (5/8in) long
(female 20mm/¾in)



Meadow grasshopper
(Chorthippus parallelus)



♂16mm (5/8in) long
(female 20mm/¾in)

Stripe-winged grasshopper
(Stenobothrus lineatus)

CHESIL BEACH AND THE FLEET

Stretching for ten miles along the Dorset coast is Chesil Beach, and behind it a lagoon called The Fleet. Together these form a landform unparalleled elsewhere in Europe. The plants they support are adapted to survive harsh conditions.

Chesil Beach is essentially a simple shingle storm beach enclosing the largest estuarine lagoon system in Britain. The lagoon–known as The Fleet–is 13km (8 miles) long and at its eastern end, at Weymouth, opens into the sea through a narrow bridged entrance less than 75m (250ft) wide. At the western, enclosed end is the famous Abbotsbury Swannery. The Fleet has been designated an area of international importance for the conservation of migrating birds and both it and Chesil Beach are graded as an *Area of Outstanding Natural Beauty* and a *Site of Special Scientific Interest*.

The sheer magnitude of Chesil Beach makes it a unique landform, and it is often quoted as being the finest European example of a tombola–a narrow sand or shingle bar which links a small island to the mainland (Chesil Beach links the Isle of Portland to the mainland).

Since Chesil Beach is so long (16km/10 miles), aerial photographs often give it the appearance of being very narrow. This is not the case. In most parts the beach is 150-200m (500-650ft) wide and up to 14m (45ft) high. The seaward, southern side often takes a battering from the sea but The Fleet side is afforded some protection by the relatively high crest of the beach.

The sheltered Fleet Protected partly from the sea by the beach lies The Fleet, a lagoon composed of a series of narrows and coves. At the Weymouth end, where the lagoon joins the sea, there is a tidal rush of immense power and range, but at the Abbotsbury end the presence of normal tides is barely noticeable. There are extensive mudflats at the Weymouth end which are exposed at low tide, but even at high tide The Fleet is extremely shallow, except for the deep channels between the mudflats.

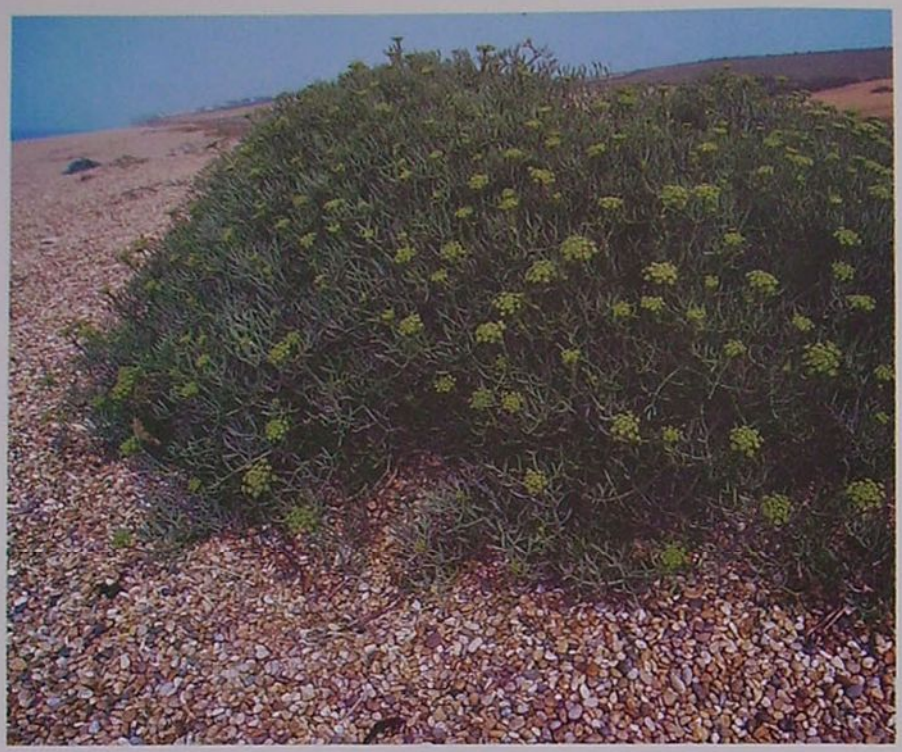
The Fleet is unique among British tidal lagoons in having a marked difference in salinity (salt concentration) along its length and contrasting conditions along its two main shorelines. The salinity in the lower third of The Fleet, near Weymouth, is much the same as in the English Channel, but in the upper two-thirds it can vary considerably depending on whether drought conditions or floods prevail. In a drought the salinity might be a quarter that found in sea water, yet during floods this may be diluted to one twentieth of seawater salinity.

The two long shorelines have very little in common, and thus add considerably to the interest of the area. The straight shoreline bordering Chesil Beach is composed predominantly of shingle whereas the opposite, landward edge is convoluted and offers a considerable variety of habitats ranging from saltwater and freshwater marsh to cliffs and cultivated soils.

Hardy beach plants As the beach is so exposed to south-westerly winds and sea spray, vegetation is concentrated on the sloping shingles facing the calmer waters of The Fleet. Plant colonization is also considerably greater at the Abbotsbury end because the finer pebbles which occur here help to trap such organic matter as guano which enriches the soil and helps to retain moisture. Vegetation is still sparse though, and the only plants to survive this harsh habitat are those that are tolerant of sea spray and can either root very deeply or withstand

Opposite page: A view of Chesil Beach and The Fleet, taken from the Isle of Portland, near Weymouth.

Below: Chesil Beach is an important national site for the yellow-horned poppy (*Glaucium flavum*). The horns are its seed-pods.



long periods of drought.

Shrubby seablite and annual seablite are two of the most characteristic, if not the most striking, plants that grow on Chesil Beach. Both have insignificant flowers, but shrubby seablite grows up to 1m (3ft) high and thrives best at the edge of the shingle where it meets The Fleet. The prostrate annual seablite is hardier and grows up the shingle bank.

Chesil Beach is a nationally important site for sea kale, yellow-horned poppy and the even rarer sea pea. The last two plants produce a fine blaze of colour made all the more spectacular because they are in flower at the same time–in mid-summer. The dainty purple flowers of trailing sea milkwort and the fleshy growths of sea purslane and glasswort further add to the contrast of plants on Chesil Beach.

Other plants on Chesil Beach typical of coastal shingle include sea wormwood, Babington's orache, sea beet, sea bindweed and prickly ox-tongue. These plants have all devised ways of withstanding drought and fierce winds: sea wormwood, for example, is covered in a fine down to reduce evaporation,

Above: Rock samphire (*Crithmum maritimum*) is a plant of southern Britain, usually associated with sea cliffs although it also grows on shingle. On Chesil Beach it is found on the loose shingle at the Abbotsbury end (shown here) and on the stable turf at the Weymouth end. Its attractive yellow flowers are in blossom from June to August.

Below: Another typical plant of the shingle beach is shrubby seablite. This thrives mainly at the edge of Chesil Beach by The Fleet, and may grow as high as 1m (3ft). It is a perennial and its flowers, which are small and insignificant, come out in July and August.

and sea beet can store considerable amounts of water in its fleshy leaves. Among the more general coastal plants growing on the shingle are thrift, rock samphire, sand cat's tail and sea campion.

Saltmarsh plants Because the northern shore of The Fleet rises steeply there is only a small area suitable for the development of salt marsh–this is in the coves along the inland shoreline. The most remarkable feature about the saltmarshes here is that plants typical of both freshwater and salt water marshes grow alongside one another.

Reeds, sedges, rushes and grasses are all common along the muddy shores. The ubiquitous common reed occurs along most of the shore but adjacent to the Swannery it forms large reed beds. Interspersed with this, where the water is least salty, is flag iris. Sand sedge, distant sedge, saltmarsh sedge and false fox sedge also grow here, and sea clubrush thrives in the shallow water.

Although these plants are the most abundant and productive of the saltmarsh they are eclipsed in summer by other species with spectacular flowers. Two of the most attractive are the blue sea aster and pink marsh mallow, both sturdy upright plants.

Algae in The Fleet The number of flowering plants that occur in The Fleet is limited, and those that are present dominate only the mudflats. Elsewhere algae thrive. Contrasting physical and chemical conditions in The Fleet have encouraged an unusual array of green, brown and red algae. At the eastern end the strongly salty water and tidal fluctuations encourage species that are normally found on the open seashore. Marine green algae such as *Prasiola* or *Blindingia*, brown algae including several species of *Fucus*, and red algae such as *Ascophyllum*, grow on old walls and boulders.

At the Abbotsbury end the characteristic algae of the Weymouth end are absent, but they are replaced by a mass of entangled species which lie on the mud surface. Sea lettuce (*Ulva lactuca*) is a common species growing alongside shining, tough filaments of *Chaetomorpha*. It is a favourite food of swans. One of the most interesting algae of The Fleet is stonewort (*Lamprothamnion*) which occurs along the shallow northern shore. This alga is confined to coastal areas of southern England, and The Fleet is one of fewer than five sites in which it is common.

Flowers of The Fleet The only flowering plants to be found in The Fleet itself are two species of eelgrass and two species of tasselweed. The rarest is beaked tasselweed which occurs in only a few isolated pockets of The Fleet. Spiral tasselweed is much more widespread and dominates the Abbotsbury end of the lagoon, growing among the algae. It is a particularly attractive plant as the stalk which holds the flowers is long and tightly coiled like a watch spring.

Of the two eelgrasses, narrow-leaved eelgrass is the most widespread and tends to

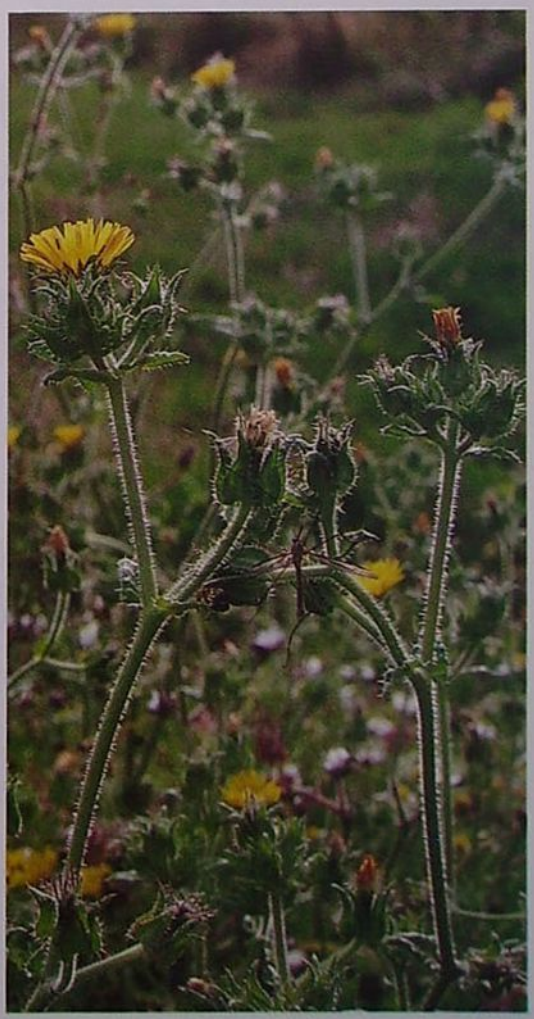
dominate the mudflats whereas dwarf eelgrass, a much smaller species, favours the coves. The success or failure of eelgrass and tasselweed spells joy or disaster for the swans and wildfowl during the winter for this is their main food supply. Without plenty to feed on many will not be tempted to spend the winter on The Fleet and large numbers of swans may die.

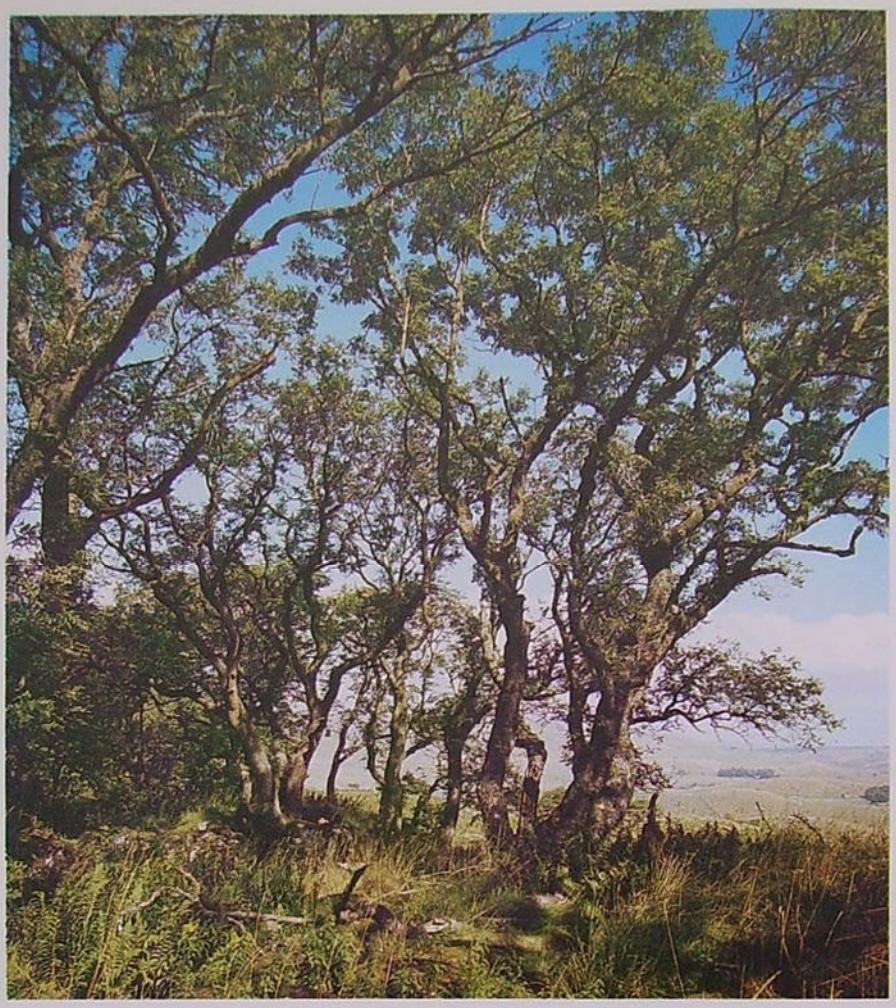
The existence of today's wildlife on Chesil Beach and The Fleet has much to do with the fact that the land has been owned by the same family for the last 450 years. Their concern in protecting it may mean that access is limited to certain parts, but at least the plants' future looks promising.

Above: A map of Chesil Beach and The Fleet showing some of the plants growing there.

Right: Prickly ox-tongue (*Picris echioides*) is a coastal plant and is able to withstand both the fierce winds and drought.

Below: The purple flowers of sea pea (*Lathyrus japonicus*) are usually a rare sight but they can be found on Chesil Beach between May and July. The seeds of this plant are dispersed by the sea.





ASHWOODS OF CHALK AND LIMESTONE

Britain's few native ashwoods are confined almost entirely to the limestone areas of the north and west and the chalk downlands of the south-east. A feature of these woods is the diversity of ground plants, encouraged by the open canopy of ash.

The pollen record shows that the ash was one of the later species of tree to arrive in Britain after the last Ice Age. Yet, once here it spread successfully to become an important component of the primeval forests of the time. To explain how the newly arrived ash managed to flourish in forests that were already long established, there is a theory that the elm mysteriously declined on a huge scale about 3000BC, enabling the ash to take its place.

When man began to interfere with the forests, the natural balance that had existed between the various tree species started to disappear. Over the last thousand years or more, he has encouraged oak at the expense of other trees because it was so much more useful to him–he allowed just enough ash in his woodlands to meet the needs of craftsmen, who required its tough, pliable wood for making cart shafts, tool handles and other items.

Nevertheless, ash is today an abundant tree of lowland districts throughout most of the British Isles, though it is sparse along the northern edge of Scotland. It is a ready colonizer, producing abundant seed, so it is common along hedgerows, roadsides and stream banks, as well as in spinneys and wild corners. The ash is a graceful tree and has been much planted on estates and parklands, both as single specimen trees and in groups or avenues. It is resistant to smoke pollution and grows well in cities, but is otherwise a rather exacting species: it prefers lime-rich ground, and so is scarce or absent in very acid districts, and it enjoys plenty of moisture at its roots.

Limestone tree Because ash can tolerate more lime at its roots than most other trees (oak included) it is the dominant species in many limestone districts. These areas are in the rainy north and west of Britain and are largely semi-upland. Here perhaps there was ash forest in prehistoric times–certainly it is here that the largest ashwoods can be found today. Such woods are well known in the Derbyshire dales of the southern Pennines, and the limestone slopes of the northern Pennines also have patches of ashwood which may likewise be relicts of primeval forest. On

Above: Colt Park Wood on the limestone pavement of the Yorkshire Dales. Ash needs lime-rich, rather than neutral or acid conditions so it is also a plant of chalky soils.

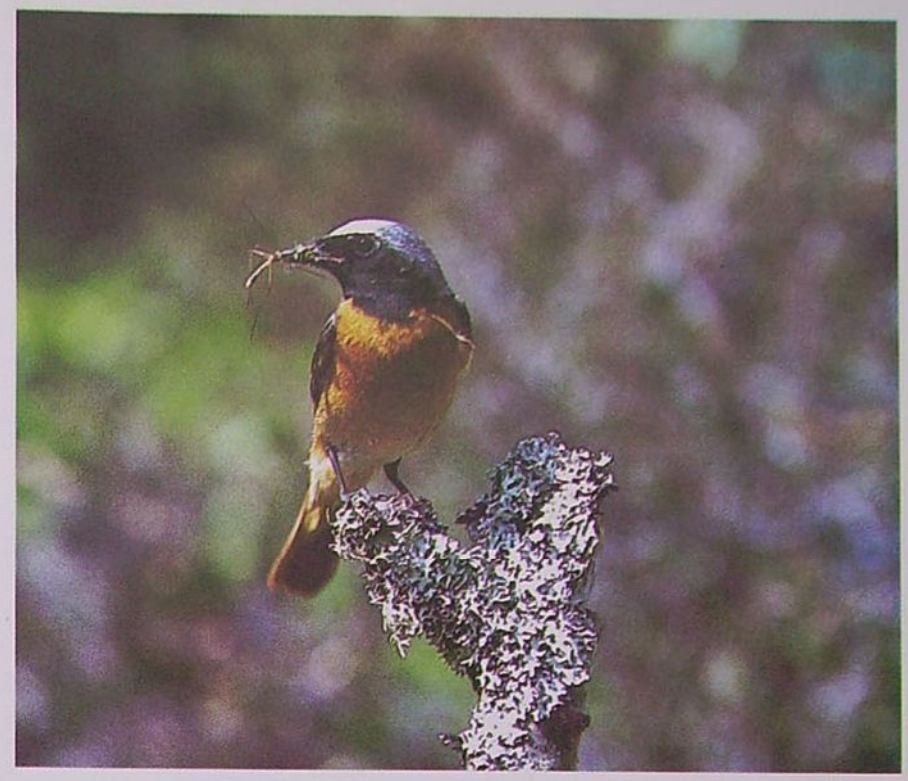
Right: One of the rare plants of Colt Park Wood is baneberry, a member of the buttercup family found only in calcareous areas. Baneberry grows to a height of 60cm (2ft) and bears spikes of white flowers.

the other hand it is possible that all the original tree cover was destroyed long ago and that the present-day ashwoods are recent colonizations. If genuine relicts of primeval forest do still exist their distinguishing feature may be the presence in them of rare or local trees such as whitebeams and small-leaved lime, which are regarded as indicators of ancient woodland.

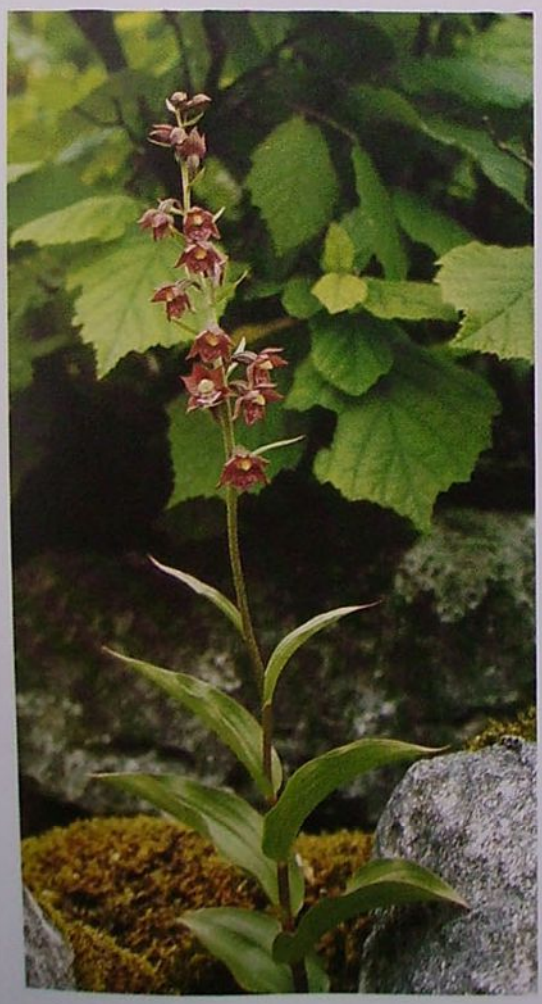
Other limestone areas with ashwoods are in the Lake District, North and South Wales, the Mendips in Somerset, the lower Wye Valley in Gwent, the Brecon Beacons National Park and parts of the Welsh border. Ireland too has many small limestone ashwoods, and there are also lime-rich sandstones in England and Wales where a few acres of ashwood have developed locally.

Although large areas of highland Britain have lime-deficient soils unsuitable for ash there are many small sites, such as damp hollows, streamsides and lower hillsides, where slight quantities of lime and other minerals accumulate by the action of percolating water. So water in a damp gully, for instance, running down a steep sessile oakwood, may gather enough minerals to support a ribbon of ash from top to bottom of the slope.

Small ashwoods are frequent in the lime-rich chalk districts of south-east England, notably the South Downs. But on chalk the ash is in competition with beech and any ash-woods are likely to be only a stage towards the ultimate establishment of beechwoods. This also occurs on the limestone areas of the Cotswolds, but competition from beech does not affect the northern limestone ashwoods because they are well to the north of the natural limit of beech forest.



Above: The insect-eating redstart is one of the handsomest birds seen in our northern ashwoods. This male has a cranefly in its beak.



Below left: The dark red helleborine can be found in the ashwoods of the Lake District. The best of these woods are between Kendal and Morecambe Bay.

Below: The fungus known as King Alfred's cakes, or cramp balls, growing on the side of an ash tree.

Northern woods Although the limestones of the north and west support the largest ashwoods their trees are often wretched specimens. Struggling against shallow rocky soils of low fertility, their trunks are mostly crooked, their branches contorted and their height very stunted. Many such woods have developed on scree that has slid down the slopes from crumbling limestone cliffs.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1 Angle-barred pug moth

2 Coronet moth

3 Ash-bark beetle

4 Goat moth

5 *Inonotus hispidus*

6 Pied flycatcher

7 Wood warbler

8 Hazel

9 Bloody crane's-bill

10 Lily-of-the-valley

11 Sanicle

12 King Alfred's cakes

Left: Some of the plants and animals you can find in an ashwood. In the **tree layer** caterpillars of the angle-barred pug moth and the coronet moth feed on the leaves, while the ash-bark beetle tunnels beneath the bark and caterpillars of the goat moth burrow into the wood. On the bark you may see the bracket fungus, *Inonotus hispidus*, and flitting among the branches might be a pied flycatcher, an insect-eater looking out for caterpillars and other prey. Lower down, in the **shrub layer**, you are likely to come across hazel, perhaps with a wood warbler in it. In the **field layer** you may find plants such as bloody crane's-bill, lily-of-the-valley and sanicle, and the **ground layer** may contain fungi such as King Alfred's cakes, which grow on both dead and living wood.

Below: A comparison of the birds and mammals in ashwoods with those in oakwoods reveals two quite different situations. The mammal species are much the same in the two habitats: for example, stoats, weasels, hedgehogs, various species of bat, and of course badgers. Among birds, however, there are far fewer species in ashwoods than in oakwoods, due to the former's lack of caterpillars.

Eventually, from the decay of mosses, lichens and other small plants, enough humus formed for the establishment of hazel and hawthorn scrub, whose seeds were spread there by birds and mammals. The scrub in its turn gave place to ashwood.

As the ashwood matured it produced ever more leaf litter which, along with rotting branches, twigs and animal matter, created enough soil among the scree to encourage lime-loving flowers and ferns to invade. Similar ashwoods have formed on limestone pavements: outcrops of rock deeply cracked by what are known as grikes. Humus gradually collects in these fissures, followed by the same succession to ashwood by way of hazel and hawthorn scrub.

Shrub layer Ashwoods often have a well-developed shrub and field layer, due firstly to there being plenty of light coming down through the thin canopy of ash foliage, and secondly due to the lime-rich, moist soils in which many plants other than ash thrive.

Hazel is often the dominant shrub in an ashwood, and both hawthorn and blackthorn may be common. There may also be thickets of young ash trees. Field maple, dogwood, buckthorn, wild privet, spindle and (in southern England) wayfaring tree are all lime-loving plants found under ash; in southern districts traveller's joy is often abundant.

Field layer The many wild flowers of ashwoods vary according to the region of the country and the different soil types. In the north you may find globe flower, green spleenwort and the rare Jacob's ladder. More widely distributed are bloody crane's-bill, lily-of-the-valley, toothwort and many others. On fertile clays, especially in the Midlands and the south, yellow archangel and nettle-leaved bellflower are particularly common.

Many of the fungi found in ashwoods occur

in broad-leaved woodlands generally.

Ashwood insects The number of insects living on ash is much smaller than we find on oak. It is, for instance, rare to see an ashwood suffering badly from caterpillar attacks. Of the 40 or so species of moth known to feed on ash (whether the foliage or other parts) the centre-barred sallow is one of the few that prefers this tree to others. This pretty orange and purple moth is on the wing in late summer to early autumn. Its colours, like those of many autumnal moths, resemble those of dying leaves and so may be of value as camouflage. Another moth commonest in ashwood country is the coronet, which is dark green or blackish and flies in June and July.

Botanists place the ash in the same family as the privet (the olive family, or Oleaceae), so it is interesting that coronet caterpillars sometimes feed on privet and, conversely, that privet hawk-moth caterpillars occasionally feed on ash.

Sometimes ash leaves are patterned with the tunnels of leaf-mining insects–usually the larvae of one or more species of very small moth (typically just a few millimetres long) called micro-moths. Other attacks an ash may suffer come from the ash-bark beetle, which excavates mines under the bark, and from the goat moth, the larvae of which burrow through the wood for several years before pupating.

Mammals and birds The fruits of ash, prolifically produced as hanging bunches of 'keys', are nutritious and eagerly sought by squirrels on the branches, and by wood mice and bank voles on the ground. Breeding birds, however, are few in ashwoods because of the lack of caterpillars relative to other woodlands. Characteristic of northern ashwoods (especially if they include birches, which are more productive of caterpillars) are redstart, wood warbler and pied flycatcher. In spring wood pigeons often come into ashwoods to gobble the flowers.

Above: Though primarily a feeder on seeds and fruits, the wood pigeon can be seen foraging for flowers in ashwoods in spring–the time of year when its main food sources are in short supply.

Below: Green spleenwort is a fern of mountainous areas, where it grows in the crevices of walls and rocks–particularly of limestone. So it is no surprise to find it in the field layer of the northern limestone ashwoods.

Two notable ashwoods Perhaps our finest ashwood is Colt Park Wood, a National Nature Reserve near Ingleborough in the northern Pennines. It grows on limestone pavement, the horizontal rock surfaces being only sparsely covered by vegetation, though the grikes, which vary in width from an inch to a yard, are rich in woodland plants. Among the commonest shrubs and trees are bird cherry, hawthorn, blackthorn, wych elm and hazel. The wood contains a great variety of herbaceous plants, ferns and mosses, many of the specimens being luxuriant. Some are rare or local: baneberry, goldilocks, angular Solomon's seal, giant bellflower and wood crane's-bill. But most of the charm of this wood comes from the lavish spreads of commoner species such as red campion, ramsons, mossy saxifrage, woodruff, wall lettuce and shining crane's-bill. Before you can visit this wood you need a permit from the Nature Conservancy Council, for too many feet trampling around would soon destroy its beauty.

Britain's most northerly ashwood is Rassal Wood near the northern end of Loch Kishorn in Wester Ross, Scotland, where it grows on a formation known as the Durness Limestone. For a long time Rassal was a degenerate wood –unfenced and uncared for , heavily grazed by sheep, deer, rabbits and hares, and with no obvious hope of regeneration. Then it became a National Nature Reserve and experimental enclosures soon showed that the wood was capable of recontructing itself into the four proper layers of a wood: trees, shrubs, field and ground. Clearly, an ashwood can grow with vigour and be rich in species, even so far north.

CAMOUFLAGE: NATURE'S CUNNING DISGUISES

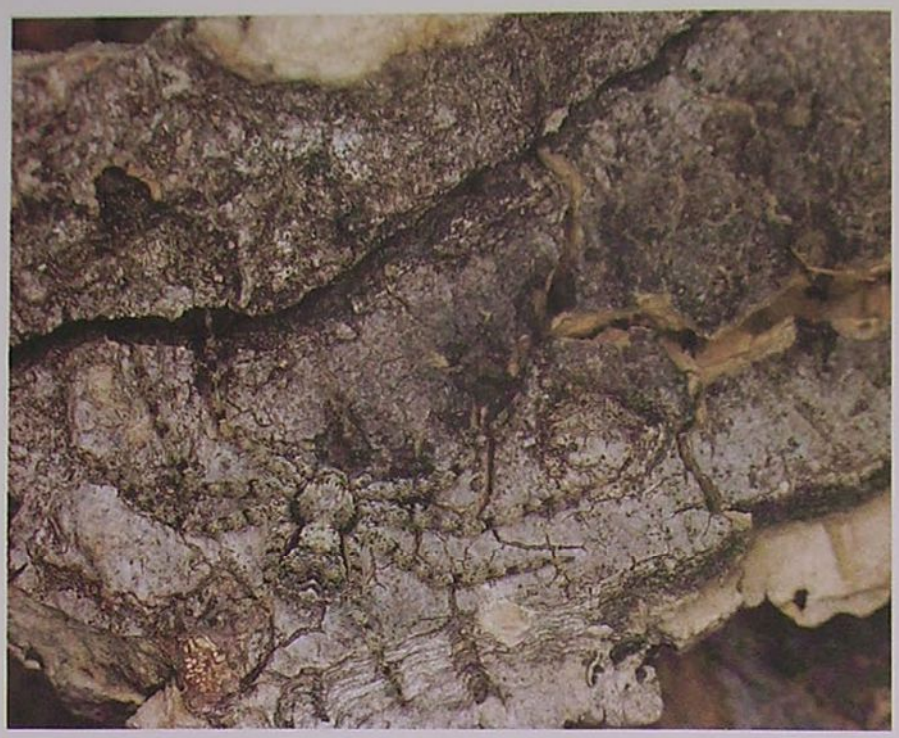
Animals which eat live food must ensure that prey does not detect their presence until it is too late to escape. For their own part, they must avoid falling prey to other animals. To achieve both objectives, natural selection has favoured the evolution of camouflage–a form of visual deception.

Camouflage is a form of visual deception in which an animal attempts to merge into the background so that it may be overlooked by predators or its prey. Although many of the best-known examples of camouflage come from the tropics, we need not travel far in the British Isles to see a whole array of adaptations to inconspicuousness and disguise.

These adaptations are most useful against animals such as birds, lizards and fishes which are active by day and depend upon sight to detect prey or predators. They are of little use against animals that rely on other senses such as hearing, smell, taste and touch. Thus the warning colours of many moths are no protection against bats, which detect their prey by echo-location, and cryptic coloration is of little use against a mole or shrew, which detect their prey by smell or touch.

Blending into the background Cryptic col-

Above: Spot the ptarmigan in her summer plumage as she nestles close to the moorland to incubate her eggs. This species is camouflaged to blend well with the heather background during summer, yet by mid-winter its brown feathers will have been replaced completely by white ones. The process takes a little time but this is ideal for the ptarmigan: patches of snow and frost in early winter go well with the patchy brown and white feathers of those months. As the snow starts to melt in spring the ptarmigan loses its all-white plumage and grows brown feathers again.
The mountain hare and the stoat also change their coat colour for winter in the Highlands.



Above: A crab spider well camouflaged on cork bark and (left) another species of the same family on bird's-foot trefoil. Crab spiders are perfectly camouflaged; many can change colour to suit their surroundings.

Below: Like other flatfish species, the colour of the brill's top side is a speckled sandy or grey brown colour, exactly matching the gravel of the sea-bed. Flatfishes can also change their colours.

oration may be found in virtually all animal groups. Among British mammals we see it in the roe deer fawn whose speckled coat merges into the background of sun-dappled leaves of the forest floor; we see it also in the coats of mountain hares and stoats which change from brown to white in winter to merge with the snow slopes of their mountain haunts. Ground-nesting birds such as the woodcock and hen pheasant are superbly camouflaged by their mottled brown and buff plumage, and many incubate their eggs right out in the open without being detected by potential predators. Often they will lay eggs blotched black or brown or grey– whatever merges best with the background. Anyone who has ever tried to find a ring plover's nest on a shingle bank will testify to the success of this strategy. The same applies to the young of many ground-nesting birds such as gulls, terns and waders.

Counter-shading Many animals use counter-shading effectively to help them merge into the background. Thus many seabirds, such as the gannet and great black-backed gull, have dark upperparts to their wings and white underparts. The upperparts when seen from above by other predatory birds blend in with the dark waves beneath, while the pale underparts are inconspicuous to their fish prey against a background of grey and white clouds. Marine mammals such as the common dolphin and fishes such as the herring show counter-shading of light and dark areas which under water tend to disrupt their outline.

Counter-shading is not only achieved by the simple gradation of colour, as in the above examples, but also by the use of bold patterns of spots and stripes which blend when viewed from a distance, for example in the adder and a number of fish. Some species have reversed counter-shading–this is most effective in the hawk moth caterpillars as they hang down on their food plants. The caterpillars of the purple emperor, on the other hand, rest in a perpendicular position with the head uppermost; the shading is darkest on the head and palest behind. The cuttlefish can alter its counter-shading by rapid colour change to suit the background on which it lies, or its orientation, with the part of the body that is uppermost being instantly shaded darker than the rest.

Changes in behaviour Concealment of shadow may also be achieved by structural or behavioural modification. Detection of animals by their shadow is most likely over open flat ground, and to avoid being caught this way animals often flatten themselves as much as possible upon the surface. The little tern chick crouches over pebbles on the beach, the shore crab flattens itself on the sand. Shadows may also be eliminated by orientating a particular way to the sun. Butterflies can reduce their shadow to a thin line by facing the sun and closing their wings above their backs. They may also tilt to one side or another, as

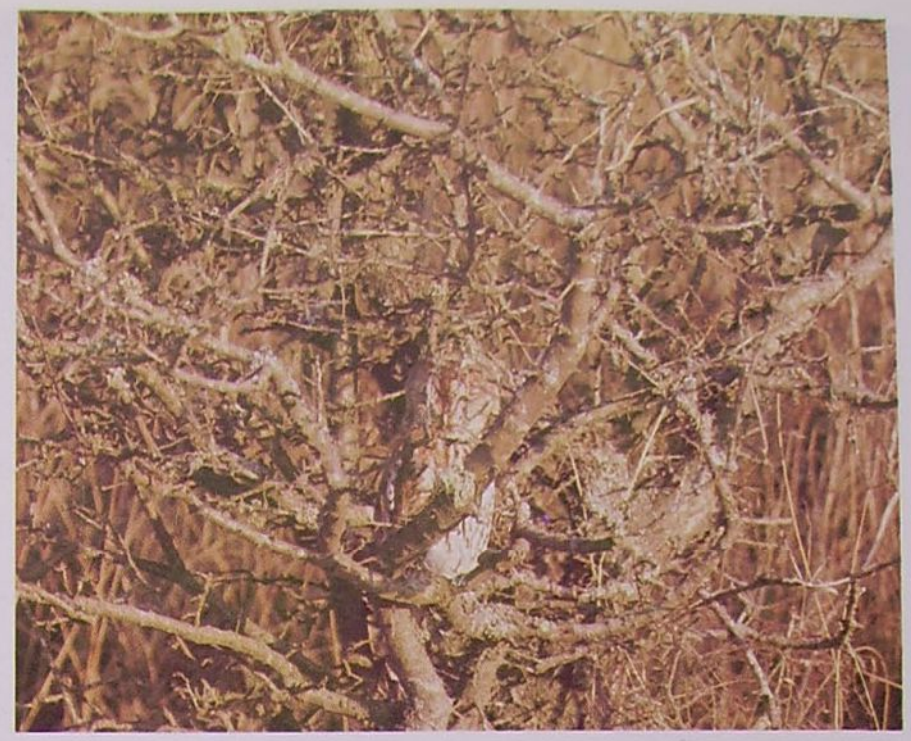
does the green hairstreak which lies almost flat against the leaf upon which it has settled.

Camouflage is obviously best achieved when an animal remains still, and a number of insect predators that sit and wait for their food to come to them are disguised to appear part of their natural background. Praying mantids and stick insects are well-known tropical examples, but in the British Isles spiders and frogs are both examples of animals which match their surroundings by their coloration.

Disruptive camouflage Some frogs have a pale dorso-lateral stripe which runs back from each eye. This, together with irregularly shaped dark patches on the back, helps to disrupt the frog's outline, particularly its bilateral symmetry. Some of these patches tend to match the immediate background, and this contributes to the disruptive effect by causing some, but not all, of the animal's outline to blend with its surroundings. The zig-zag pattern over the back of a number of snakes such as the adder serves a similar disruptive function, making smooth surfaces appear as a random collection of black or brown or grey leaf-like surfaces.

Disruptive coloration may also work by making various parts of the body of an animal appear joined together, so disrupting the characteristic shapes of different parts. For example, many cryptic moths that rest on tree trunks have a bold disruptive pattern which runs continuously across both pairs of wings and the body. This pattern must nevertheless blend with the surroundings to be effective. The classic and much quoted example of this is the peppered moth.

A similar example of the importance of predation in evolution for moulding the appearance of animals is to be found in the land snail *Cepaea* which is eaten by a number



Above: A roosting tawny owl, and (below) a woodcock guards its nest among dead leaves in a wood in spring, both blending into their backgrounds with their mottled brown and buff plumage. This cryptic coloration is an effective defence against predators.

Right: A brilliant deception: the head of a buff tip moth resting on a twig and mimicking it exactly. Only the most experienced eye could distinguish the two.

of insectivorous birds, notably thrushes. This snail has many distinct forms (and so is referred to as polymorphic)–it may be yellow, pink or brown, banded or unbanded, and if it is banded the number of bands may vary. Although these different morphs are partly determined by environmental conditions (for example, brown forms overheat at high temperatures more readily than yellow forms) an important factor determining their distribution is the habitat in which they live and the degree of concealment the habitat offers from bird predators.

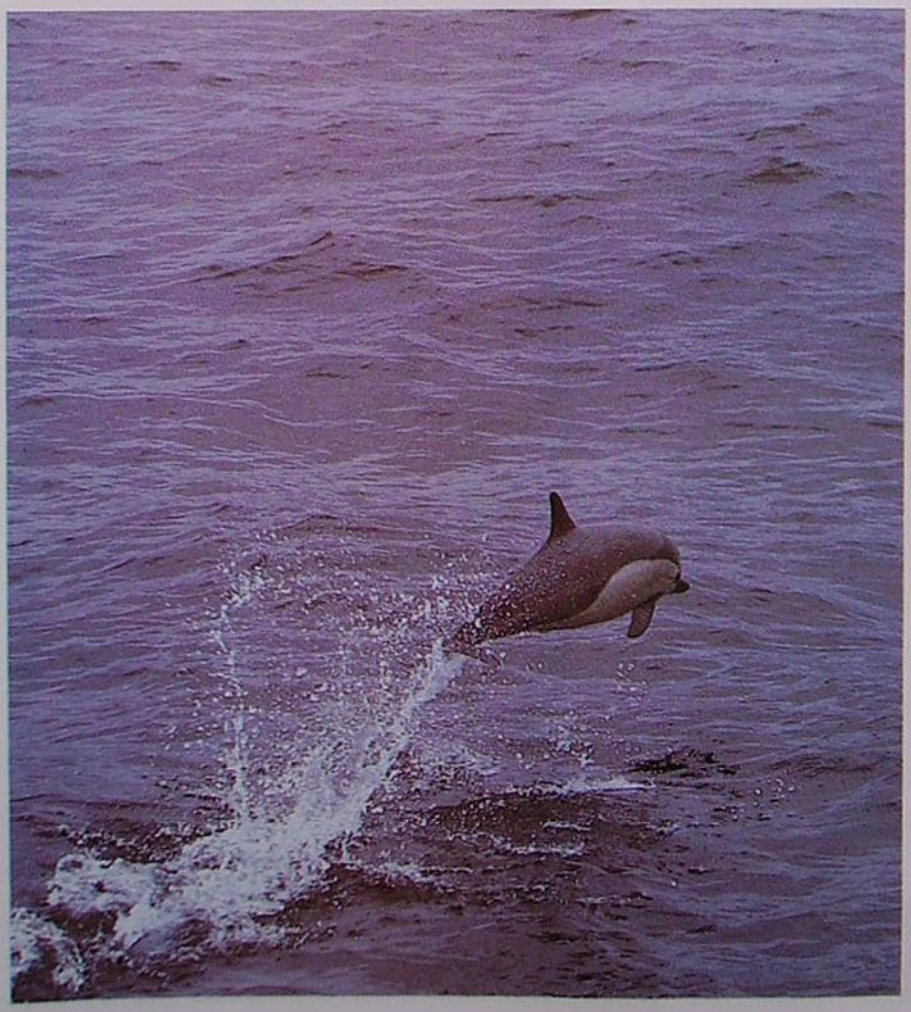
A bad taste in the mouth Many animals protect themselves by producing nauseous tastes or smells, or by inflicting painful or poisonous stings. Obviously it is important that a potential predator recognizes that the prey is noxious, preferably before it has taken a bite out of it, both for the sake of the predator as well as the prey. Such animals are usually brightly coloured with bold contrasting patterns of black, red, orange, yellow and white. Examples are bees, wasps, ladybirds and the striped caterpillars of the cinnabar moth. They may also make themselves more conspicuous by clustering together in large groups or by resting in exposed positions, or by emitting sound signals, such as a loud buzzing noise.

Animals with warning coloration (termed aposematic) are often difficult to kill, having tough skins or elastic tissues which simply spring back into shape after the animal has been released. This is an important adaptation because, for warning coloration to be successful, predators must learn by experience which animals are palatable and which best left. To do so they must suffer a few unpleasant experiences and learn to associate them with the bright colours of the animal concerned.

Above: The larva of a purple emperor butterfly is almost indistinguishable from the leaf.

Right: The bright markings of the five-spotted burnet moths remind experienced predators that they exude poisons if they are attacked.

Below: A leaping dolphin shows its pale underside: counter-shading makes an animal less conspicuous from a distance by counteracting shadows caused by overhead light.



Although warning coloration is perhaps most important among invertebrates, it is also found in other animal groups. Many fishes have striking patterns, like the black and white stripes running along the body of the catfish, or the black and white throat markings and white spots on the puffer-fish. Neither makes much attempt to conceal itself, and puffer-fishes generally manage to survive attacks from inexperienced predators by inflating themselves with air or water so they become difficult to swallow. Most aposematic animals are diurnal and their warning colours are readily seen in daylight, but some nocturnal mammals are noxious and possess conspicuous patterns, particularly over their face

Above: A wildcat and her kitten rest in a tree, their striped coats helping them to merge into the habitat.

or running along their backs. In Britain mustelids such as the polecat and badger show this patterning. In many cases these markings probably also serve a social function.

It is important that an animal with warning colours has toxic or nauseous properties which are neither so strong as to be lethal nor so weak as to be ineffectual. Their poison is usually combined with an emetic causing the predator to vomit. Animals with warning colours must tend to be scarce in comparison with cryptic species, otherwise predators would quickly evolve adaptations to exploit such conspicuous sources of food. Occasionally a species has evolved ways to capitalise on this: the European cuckoo takes hairy caterpillars that are noxious to other species. Some defenceless animals daringly make use of warning coloration to mimic distasteful or noxious species. All are harmless, but will be avoided by predators which have been stung by a genuine poisonous species.

To avoid unnecessary losses, many animals, especially insects, use the same combinations of colours. The black and yellow bands of wasps are recognised by predators as an international warning of a creature to be avoided. This economy of colour pattern helps both mimic and predator: the latter needs to learn only a few patterns, while the former is less likely to be eaten.

Below left: A wasp beetle feeding on spurge. A number of defenceless animals use warning coloration to mimic distasteful or noxious species –the hoverfly, wasp beetle and hornet clearwing moth are all mimics of wasps and hornets. All are harmless but gain protection by the avoidance of predators which have been stung by a genuine wasp or hornet. These are termed Batesian mimics, after the English naturalist H W Bates, and are widespread among insects: ants are mimicked by spiders; ichneumon wasps by bugs, cockroaches and dipteran flies; bombardier beetles by grasshoppers; ladybirds by cockroaches.

Right: Another form of mimicry–Müllerian mimicry, named after the German biologist Fritz Müller–relies on harmful animals bearing a mutual resemblance to each other: adders have a zig-zag pattern that is similar to patterns of other toxic species.

FRITILLARY MEADOWS

In late April and early May the delicate blooms of snake's-head fritillary are at their best, flowering amid the other wetland plants of our ancient flood meadows.

Fritillaries, like so many other members of the lily family, have captured the imaginations of gardeners for centuries. About 85 species exist in the genus but there is only one British representative among these exotic bulbous perennials.

Snake's-head fritillary and snake-in-the-grass are the most common names for our native species, but in areas where it was once very common local names such as oaksey lily, chequered daffodil, drooping tulip and mourning-bells-of-Sodom were used to describe this charming yet curious plant.

In common with many bulbs, snake's-head fritillary blooms comparatively early in the year so seed production is over by July when hay-making traditionally begins in its favoured habitat, flood meadows. The fruit capsule is spherical but slightly three-sided, and contains numerous flattened winged seeds. Fritillary flowers are usually solitary and borne on slender stems reaching about 50cm (20in) in height, each stem having three to six long, narrow grass-like leaves that are alternately arranged along its length.

Vanishing flood meadows Sadly, the snake's-head fritillary is no longer a common plant. The grazing or picking of plants has been partly responsible, but the main cause of its dramatic demise in numbers–and even entire populations–can be attributed to changes in land management. Fritillaries thrive exclusively in our ancient flood meadows and it is these very meadows which are suffering from the modern agricultural practice of land drainage. Although the loss of water makes the land more manageable for farmers, it has a drastic effect on the habitat, and the first to suffer are such plants as snake's-head fritillary which depend on damp conditions for their existence. Once sufficiently dry the land may be ploughed up for crop cultivation, completing the destruction of the flood meadows which provided such ideal growing conditions for fritillaries.

Another cause for the decline in fritillaries and associated wetland plants is the application of artificial fertilisers to the land. In contrast to farmyard manure, which is a good

Above: The best sites for fritillaries are the flood meadows along the upper Thames and in East Anglia. These meadows have been managed in the same way for centuries: in July the grass is cut for hay, left to regrow a little in August and then subjected to livestock grazing from September to November. The livestock may remain there, if it is not too wet, until the following spring when they are taken off the land, and the grass–along with many spectacular flowers–is allowed to grow. Up to a hundred plant species have been recorded in flood meadows flourishing alongside the fritillaries: cowslip, meadow rue, pepper saxifrage and orchids to name but a few. Sadly, though, the floral composition of these meadows has undergone drastic changes since World War II, partly because of the increasing use of artificial fertilisers, and partly because of land drainage schemes making conditions generally drier.

meadow fertiliser causing no harm to the plants, the high concentrations of chemicals found in most modern fertilisers are highly damaging to the more delicate wild flowers.

A vulnerable species Snake's-head fritillary was known to occur in 27 counties in the British Isles before 1930, but by 1970 its distribution was reduced to nine counties. The Biological Records Centre keeps a watchful eye on changes in the distribution of various plant species in the British Isles and uses 10km squares (tetrads) as its basic reference unit. If a species is found in fewer than 15 tetrads it is considered to be near danger level and is classified as endangered, rare or vulnerable in the *British Red Data Book* for vascular plants. Snake's-head fritillary, along with 300 other British plants, is considered a vulnerable species as, by 1970, its distribution had shrunk from 116 to 15 tetrads.

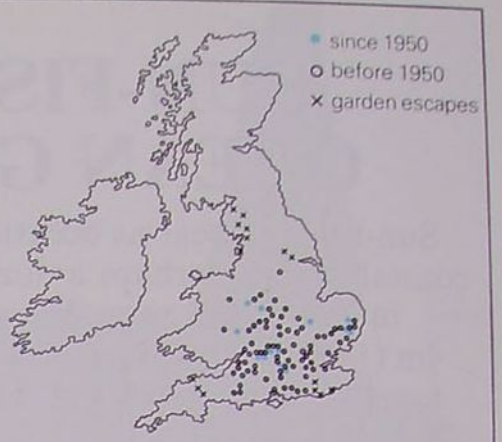
North Meadow The largest fritillary population has over 50,000 plants and is contained within the boundaries of the National Nature Reserve at North Meadow, Wiltshire. This may seem a large number but it represents 80% of the total British population of fritillaries. The 44ha (109 acres) of land are now owned largely by the Nature Conservancy Council, and they are of particular interest for they consist of ancient meadows, the management pattern of which has remained more or less unchanged for the last 800 years.

Traditionally the meadow is laid up for hay annually on February 13 and left until early July before it is cut. Lammas Land, as the area is known locally, is sectioned into lots which the local people buy for hay. On August 12, known as Lammas Day, the meadow becomes common pasture and an ancient system of land tenure ensures that any resident of Cricklade can graze 10 horses, 10 head of cattle and 20 head of sheep from September 12 until the following February 12.

It is largely because of the existence of common rights that North Meadow has developed its uniquely rich flora. The system is a very effective stabiliser of land use as no individual could obstruct the rights of others by, for example, ploughing his lot.

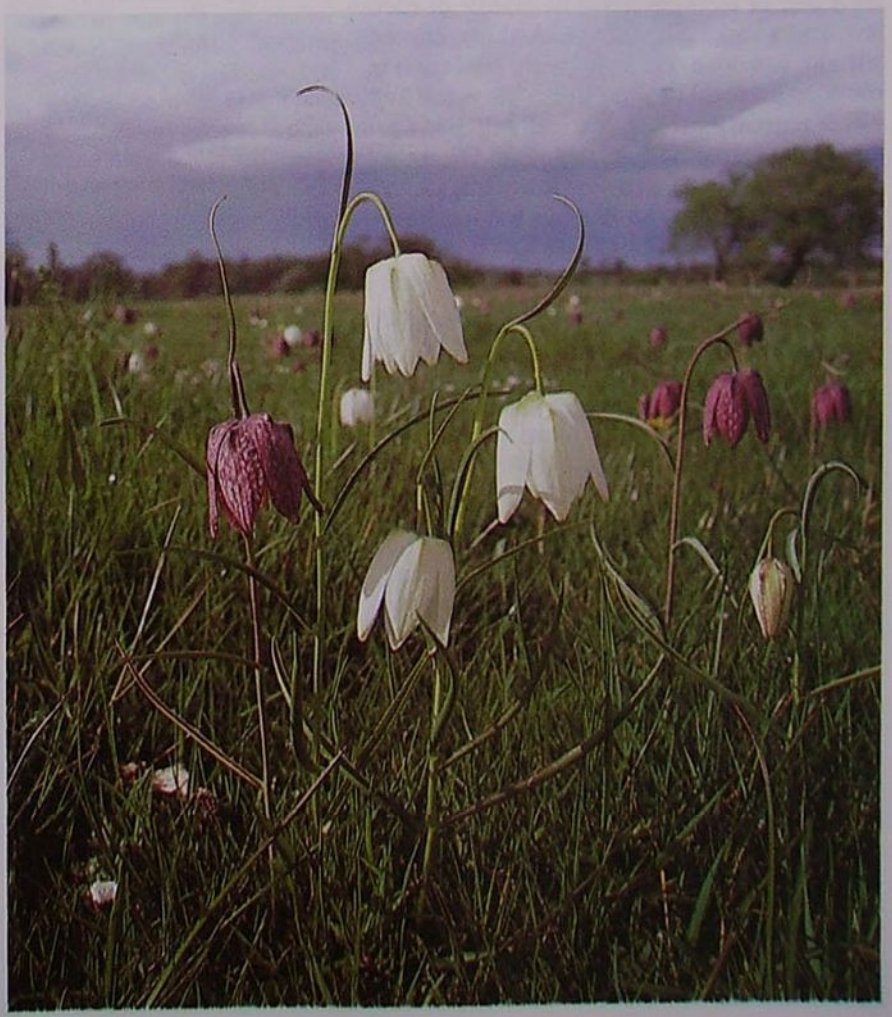
White fritillaries Although North Meadow supports the largest population of fritillaries, other sites with smaller populations are equally interesting since no two meadows are ever identical. Variations in altitude, aspect, topography, substrate and (ultimately) management all play their part in creating a unique habitat. A similarly well-balanced meadow to North Meadow, found where Berkshire and Hampshire share a common boundary, is well known locally for its fritillaries. Large numbers of white-flowered forms are common, often appearing to be in the majority because of their conspicuous brightness. The meadow is privately owned, but managed in conjunction with the local naturalists' trust.

Fritillary sites
This distribution map shows how the sites where fritillaries occur (represented by a dot) have declined dramatically since the 1940s. Nowadays the flood meadows in which they thrive are located mainly along the banks of the upper Thames and in East Anglia, but prior to 1950 they occurred throughout much of southern and central England.



Right: The fritillary flower, similar to an inverted tulip at first sight, comprises six petals, each with a shiny nectary at its base. Its six stamens are a golden yellow. Fritillaries are often pollinated by bumble bees, but should the insects fail to visit, the flowers can pollinate themselves.

Below: The white-flowered form of fritillary is quite common, growing in profusion in a meadow along the Berks/Hants border.



SUN-FISHES: OCEAN GIANTS

Sun-fishes appear as occasional vagrants in our coastal waters, perhaps a dozen sightings occurring in an average year. The ocean sun-fish is a 4m (13ft) giant as heavy as three Hereford bulls together, attaining a weight of a ton and a half.

Right: An immature specimen of ocean sun-fish found in the tidal Thames near London. It probably drifted in from the English Channel, coming originally from the Atlantic. A very similar migration brings many other oceanic animals into our waters, and often to their deaths in the cold of the winter-time North Sea. Among these are such fishes as the skipper (*Scomberosex saurus*) and Ray's bream (*Brama brama*), and also the leatherback turtle (*Dermochelys coriacea*) which, like the sun-fishes, is another giant of the North Atlantic that relies on jellyfishes for food. By the time these warm-water creatures reach our coasts they are often helpless with cold.

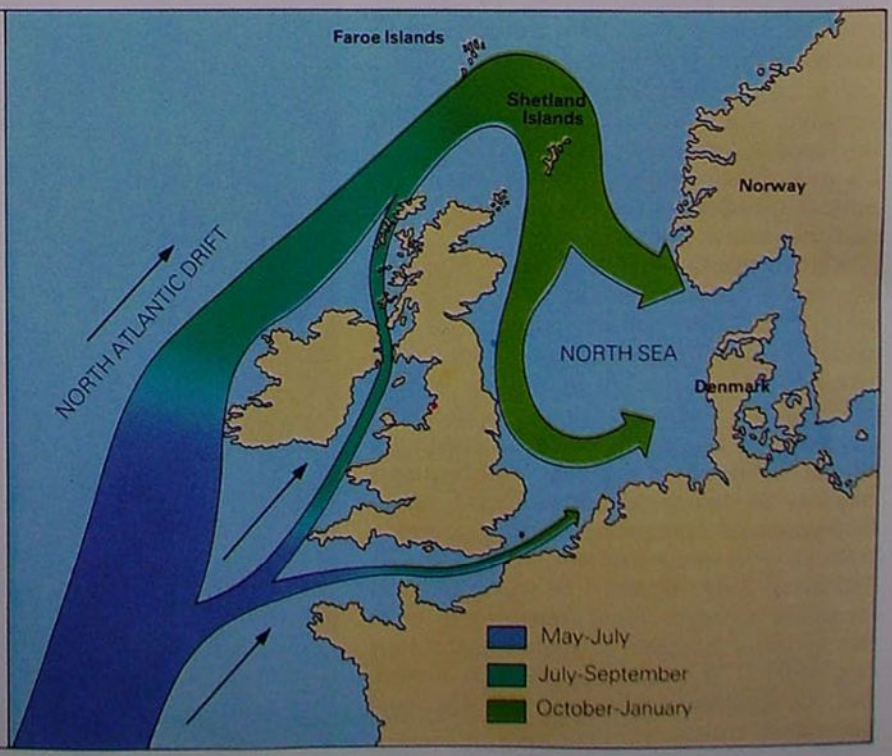
In common with many other large marine animals, sun-fishes are a group whose natural history is little known. It is one of the paradoxes of zoology that very few of the largest animals have been as well studied as small or medium-sized creatures. But this is even more remarkable because often when a sun-fish is found or captured its curious shape excites great interest in newspapers and sometimes on television. Frequently their size is noteworthy too.

Unusual appearance A sun-fish looks simply like a huge head with two fins attached at the top and bottom, just where the body would be expected to start. Seen from the side it is almost circular with a small mouth, containing a pair of teeth fused in the middle of each jaw, and a small circular eye. A short, curved gill slit can also be seen, with behind it a rounded pectoral fin. The dorsal fin is tall and rather narrow, with an identically shaped anal fin beneath, just behind the vent. Where all other fishes have a more or less elongate tail ending in a fin, the sun-fish has a thick, fleshy lobe with an uneven edge, which is its entire tail and tail fin.

The jaws and teeth, and the very small gill openings, give a clue to the order to which the sun-fishes belong, for they are highly modified relations of the tropical porcupine fishes, puffer-fishes and trigger-fishes, all of which have similar features. But the sun-fishes have become adapted for a life in the open sea. As they grow to a large size, few predators trouble them–at least as adults–and so they have dispensed with the strong spines and prickly skins of their shallow-water tropical relatives. However, the skin is rough to the touch, and thick, overlying a tough, fibrous layer of tissue which may be up to an inch deep

Drifting into winter

Both our species of sun-fishes tend to drift where the ocean's currents take them, and this accounts for the seasonal nature of their occurrence on the coasts of the British Isles. During the summer they move northwards from equatorial waters, and some are then transported north-westwards by the North Atlantic Drift. Of those that reach the British Isles, some are carried into the English Channel and others into the Irish Sea, but the majority pass along the western coast of Ireland and later Scotland. Many are carried further north to Shetland and southern Norway, but others are swept into the North Sea and move southwards, at first along the eastern coasts of Scotland and north-east England, before being carried by the currents across to the Danish coast. By the time they are off the north-east coast of England it is winter. Fishes numbed by the cold are stranded helpless on the shore, while others are found floating at the surface, incapable of swimming. They are not likely to survive and will certainly not breed in this country.



in large specimens. This gives it good protection, and acts as thermal insulation too.

Two species Sun-fishes are found worldwide in tropical and temperate oceans. There are probably only four species, and two of these are found off our coasts and occasionally strand themselves on the shore. The largest and most frequent is the ocean sun-fish (*Mola mola*) which has an almost circular body, can be 4m (13ft) from head to tail, and can weigh about 1500kg (3300lb). It is a truly massive fish. The slender sun-fish (*Ranzania laevis*), sometimes called the truncated sun-fish, is very modest in size, growing only to a length of about 80cm (31in), and its weight is rarely more than 10kg (22lb).

The slender sun-fish Compared with the ocean sun-fish, the slender sun-fish is uncommon, and has been reported in the waters of the British Isles probably on about 20 occasions. It is a very distinctive and beautifully coloured fish. It shares the general features of its larger, more common relative, with a deep, laterally compressed body, but its body is relatively elongate, being about twice as long as high. It, too, has long blade-like dorsal and anal fins, and these are placed at the far end of the body, while the tail fin is a narrow lobe.

The slender sun-fish is, as its name indicates, narrower than its relative and has an almost knife-edged belly. Its back is deep blue, with metallic silvery sides, and brilliant silvery, black-edged stripes curving across the head and belly. The contrast in coloration between this species and the ocean sun-fish could not be more marked, for the latter is a drab brownish grey above, the sides paler, and the underside grubby white.

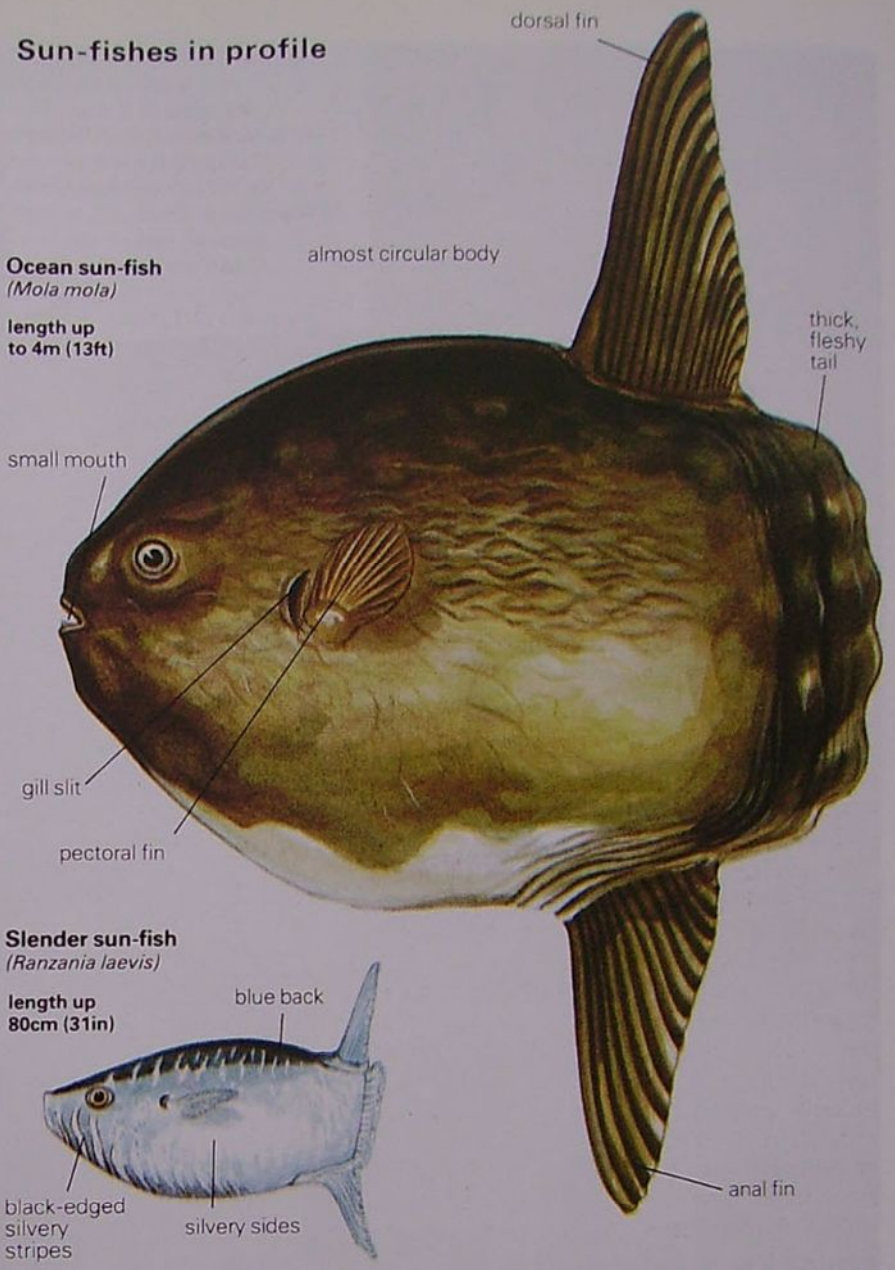
Frequency of sightings The slender sun-fish has been recorded mostly on the south-western coasts of England and Wales, and on the west coast of Ireland. There was a report of one off Whitby, Yorkshire, in November 1867, but as it was said to be 1.5m (5ft) long it was probably a case of wrong identification.

The ocean sun-fish has been recorded all round the coast of the British Isles. It has been reported in all months of the year. Analysis of the several hundred dated records shows that in the south and south-west most are for the months of May to August, on western coasts they occur from July to October, and in the north and especially in the North Sea occurrences are mostly between September and January. This time scale is important in that it indicates where the sun-fishes on our coasts originate.

A natural drifter The ocean sun-fish seems to be a wanderer on the high seas. Most reports of the species describe the fishes as floating gently, often on their sides, near the surface, and this led to the belief that they basked at the surface in the sun and spent their lives paddling around in this ineffectual way. The truth is more probably that these fishes at the surface are sick, or chilled, having come up from the warmer mid-waters to the air-cooled surface waters. In health they swim upright, propelling themselves with powerful strokes of the dorsal and anal fins in a twisting action to the same side simultaneously. They can move surprisingly fast when their bulk is taken into account.

For all their enormous size and floppy appearance when landed, they are agile in water, for they weigh much less than their size might suggest; their skeletons are paper-thin and contain very little calcium, and their muscles are soft and watery. In water they 'weigh' very little.

Food of the sun-fish This has not been extensively studied, and there are conflicting reports of it, probably because most sun-fishes that have been dissected were either sick or stranded fishes found in shallow water. There is strong evidence that healthy sun-fishes feed mainly on jellyfishes and comb-jellies (ctenophores), and this would be in keeping with their mid- to surface water life-style in the oceans. Fish larvae and crustaceans also feature in their diet.



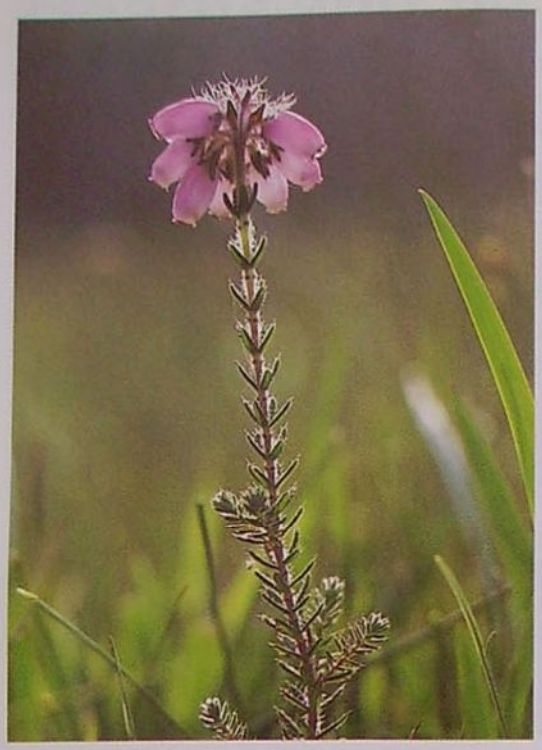
Above: Britain's two sun-fish species; the difference in size is greater than in this illustration, for in life a fully grown slender sun-fish is less than a quarter the length of the ocean sun-fish. It should also be noted that their roundness of shape is apparent only in the vertical plane: seen head-on, they are both narrow-bodied. Little is known about the breeding behaviour of sun-fishes; neither fertilised eggs nor early larvae have been found, so it is not known where they breed. It is known, however, that the ocean sun-fish produces up to 300 million eggs when large, making it probably the most fecund fish in the world.

HEATHERS OF THE BRITISH ISLES

Only South Africa can boast more species of heather than the British Isles. Nearly all the species demand acid soils and so it is on our moors, heaths and bogs that they usually grow, forming carpets of purple and pink flowers in late summer.

Eleven different heather species grow in the British Isles: eight species of *Erica*, one species of *Calluna*, one of *Andromeda* and one of *Daboecia*. All are low evergreen shrubs and, with the sole exception of Irish heath (*Erica erigena*), require acid soils, growing at their best on moorland and heathland, and in bogs.

To ensure accurate identification of heathers you must examine them carefully: *Erica* species have needle-like leaves borne in groups of usually three or four, although sometimes there are as many as six. The corolla is bell-shaped and much larger than the tiny green calyx. *Calluna* has opposite pairs of tiny, stubby, stalkless leaves and each leaf has small projections at the base. The

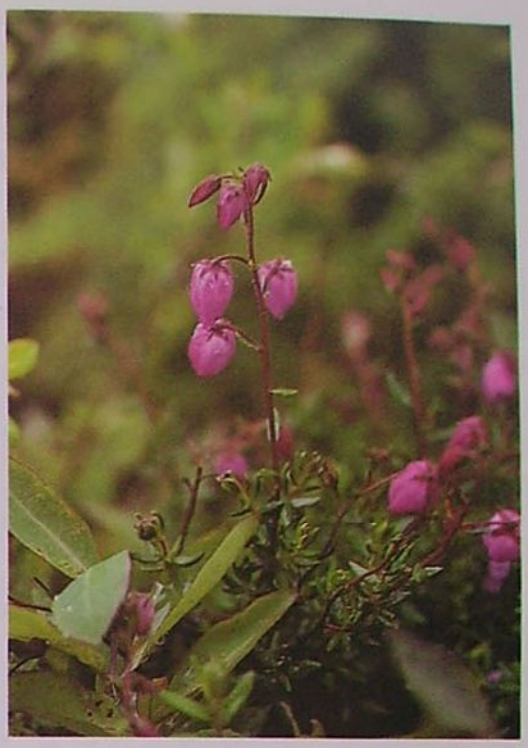


Left: Cross-leaved heath is typically a bog plant although if there is no competition it can also grow on relatively dry soils. It is a hardy species, found as far east as the Baltic countries–a contrast to bell-heather, another common heath, which is very much an Atlantic plant. The flowers are usually rosy pink but occasionally you may come across a white form; the calyx is green.

Right: St Dabeoc's heath, native only to Mayo and the west of Galway in Ireland, can sometimes be found as an escape in England.

Opposite page: Heathlands become covered in a blaze of purple and pink flowers when the heathers are in bloom in late summer. Here is a view across Rockford and Ibsley Commons in the New Forest.

Below: Cornish heath is native only to the Lizard peninsula in Cornwall where it thrives mainly on the alkaline serpentine rock. (This species is more tolerant of alkaline soils than most heaths.) It occurs in a number of interesting forms including the white form seen here.



calyx is typically longer than the corolla and both are the same colour. The broad leaves of *Daboecia* are dark green above but white underneath and its rose-purple corolla is quite large. *Andromeda* has narrow dark green leaves which are glaucous (bluish) beneath; the pink corolla is 5-7mm long, much the same size as in most species of *Calluna*.

True heather The three most common species in Britain are ling in the genus *Calluna* and bell-heather and cross-leaved heath, both in the genus *Erica*. All come under the collective term heather, but this name applies strictly only to ling–the others are correctly known as heaths. These three species grow throughout the British Isles although their distribution is limited by their requirement for acidic soils, in which few other plants grow. On these acid soils they may cover vast expanses creating quite a spectacle in late summer when the flowers are out, but also providing food for various birds (notably grouse), sheep and insects, especially bees.

Ling (*Calluna vulgaris*) is an extremely variable plant with over a thousand varieties so far recorded and more being added to the list every year. The forms vary from tiny, compact dwarfs to lanky plants reaching 1.5m (5ft) high. The leaves are hairy and may be green or grey, tipped with bright red or orange which becomes yellow in summer and then turns bright scarlet, crimson or orange in winter. A number of freak plants also occur with such characteristics as variegated or unusually coloured foliage. Ling flowers normally range in colour from pink to deep crimson and may be single or double.

White-flowered plants also occur sometimes, although they would be more common in the wild if people resisted the temptation to pick them. (The notion that white heather is lucky is unknown outside areas of British influence and seems to have originated as recently as the reign of Queen Victoria.)

Common heaths The widest range of flower colour is shown by bell-heather (*Erica cinerea*). Variations include rosy-purple, crimson, brick-red, bicoloured, almost black, and extremely pale. Some curious flower forms also appear from time to time. Perhaps the most remarkable are those with split petals (known as schizopetalous flowers) in which the bell-like corolla is split into four equal segments, giving it the appearance of a totally different plant. Such plants are fertile and can produce similar schizopetalous plants, but some revert to the normal bell-shaped flower.

Cross-leaved heath (*Erica tetralix*) thrives in bogs but if relieved of competition it can also grow reasonably well on dry soils. The leaves are often silvery grey and the flowers rosy pink or occasionally white. There is one from, *Erica tetralix* var. *fissa*, the flowers of which have ragged corollas in early summer. These are caused by mites which chew them into uneven tatters; later in the year the flowers are normal. Despite having a botanical name, therefore, this form is not a true botanical variety.

Atlantic species Like bell-heather, a number of heaths are common only on the western seaboards of Europe and are known as Atlantic species. One such example is Irish heath (*Erica erigena*) which attains its full glory in western Connemara where it flowers in spring and early summer, This heath grows over quite an extensive area, often along the fringes of lakes and in two places, at least, it covers the hillside.

Another heath with a similar distribution is Mackay's heath (*Erica mackaiana*) which grows only in Connemara, Donegal and northern Spain. This species has two odd characteristics: in Ireland the spread is entirely vegetative with seedlings being unknown; and it is also the only *Erica* known to produce double flowers.

Heathers of the south-west Dorset heath is now the accepted common name for *Erica ciliaris*, although it occurs most profusely in Cornwall. The species was first found in Cornwall in 1828 but could not be called Cornish heath because the name had already been used for *Erica vagans*, found 160 years earlier. Dorset heath is yet another Atlantic plant found along the western coasts of Europe. The most northerly site for this plant is in Connemara where there are six stocky old bushes but hardly any seedlings.

Above: An attractive plant, bog rosemary used to be widespread in northern England, the Scottish lowlands and Ireland. Now, however, it is becoming rarer as its favoured habitat–boglands–are drained under land reclamation schemes.

Below: Ling and bell-heather growing side by side in the New Forest where both species are extremely common. The paler, lobed flowers on the right are those of ling.

Although Cornish heath occasionally occurs as an escape from cultivation, it is native in Britain only on the Lizard peninsula in Cornwall. In much of that area it is the dominant ground cover, kept low by the winds that sweep across the peninsula.

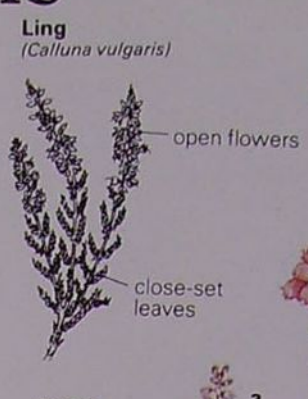
On the exposed cliffs of our western seaboard many plants often appear flattened by the wind but away from the exposed sites such plants may grow taller and have a more upright stance. This is not so with at least some of our cliff heathers which stay attractively prostrate and compact even when grown in more sheltered locations. Another strange fact is that western cliff heaths are more often white-flowered than plants from elsewhere. The reason for this remains a mystery.

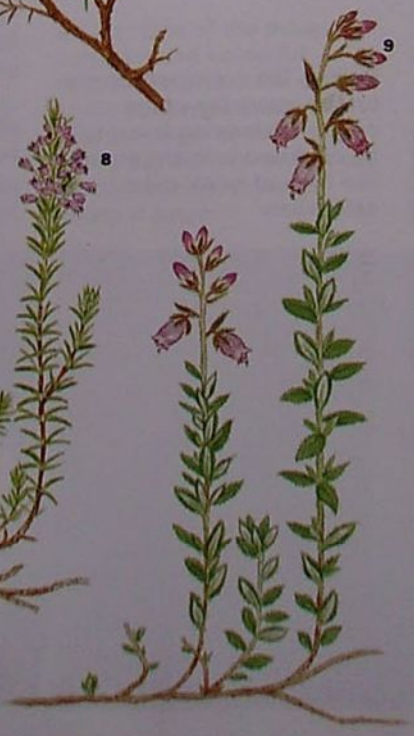
Extreme rarities The remaining two heaths native to this country are bog rosemary and St Dabeoc's heath. The former used to be widespread in northern Britain and Ireland but its distribution is diminishing as more and more bogs–its favoured habitat–are drained. St Dabeoc's heath can sometimes be found as a garden escape in England but it is native only to County Mayo and west Galway in Ireland.

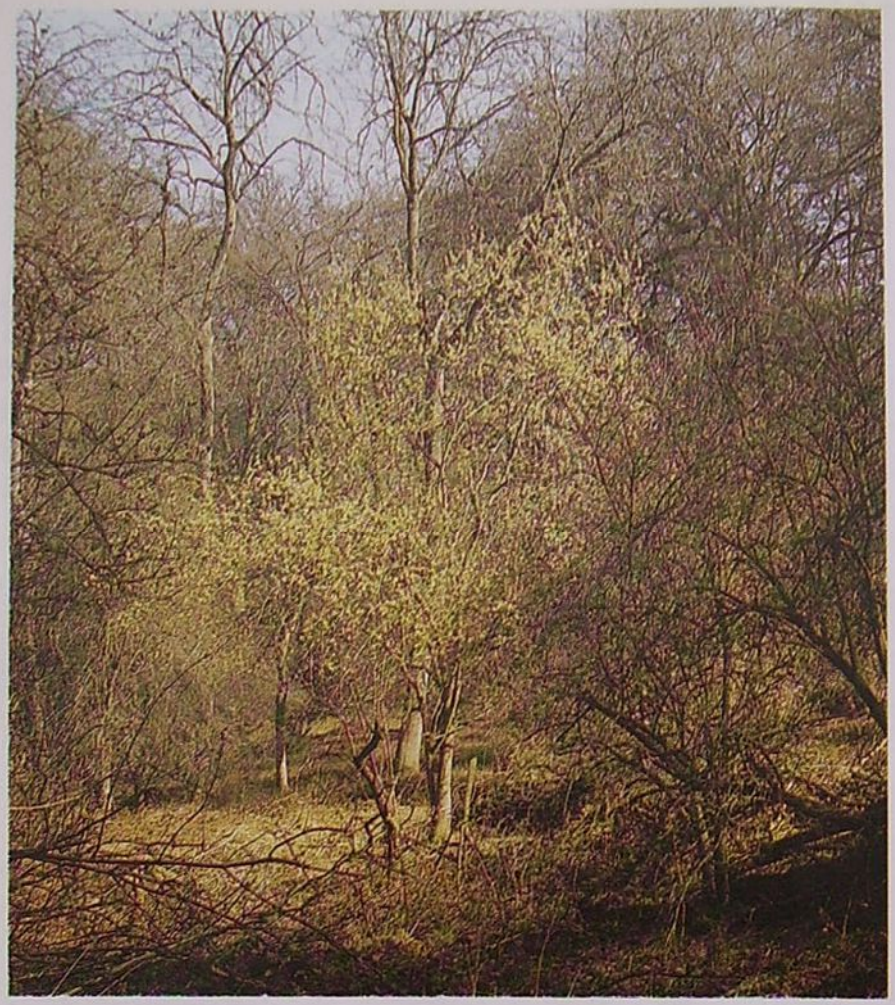
Two heathers from southern Europe have become naturalised in the British Isles. In about 1876 *Erica lusitania*, a tree heath from Portugal, appeared at Lytchett Heath in Dorset. It was also planted along railway lines in Cornwall at the beginning of this century, where it became established in several places. *Erica terminalis*, a hardier, flowering tree heath escaped by seed from a garden near the Magilligan dunes in County Derry early this century and soon formed a thriving colony. Curiously it has not become established elsewhere in the British Isles.

Heaths and heathers

1 **Cross-leaved heath** (*Erica tetralix*).
2 **Bell-heather** (*Erica cinerea*).
3 **Ling** (*Calluna vulgaris*).
4 **Irish heath** (*Erica erigena*).
5 *Erica terminalis*.
6 *Erica lusitanica*.
7 **Dorset heath** (*Erica ciliaris*).
8 **Cornish heath** (*Erica vagans*).
9 **St Dabeoc's heath** (*Daboecia cantabrica*).
10 **Mackay's heath** (*Erica mackaiana*).
11 **Bog rosemary** (*Andromeda polifolia*).







Above: Sallows are most readily recognised by the fluffy cream and yellow catkins they produce in spring. The great sallow (shown here) has a tree-like growth, by which it can be told apart from the more bushy grey willow.

MOTHS OF SALLOWS

A fascinating insight into our native species of moths can be gained by spending a few hours in May, June or July searching your local sallow bushes for moth caterpillars.

One of the most fruitful places to seek moth caterpillars is on the foliage of our native sallows and willows. With the exception of oak, these plants are host to a greater number of moth species than any other native plants. The caterpillars of at least 150 species of the larger British moths feed on sallows. These include some of the most attractive and distinctive British species.

The sallows fall within the plant family Salicaceae, which includes all the willows and poplars. The species most favoured by moths are the common sallow, or grey willow, (*Salix cinerea*) and the great sallow, or goat willow, (*Salix caprea*). These species often form bushes or small trees in hedgerows, where regular cutting encourages them to produce succulent shoots which are much sought after by egg-laying moths.

The reason why the caterpillars of so many moths feed on sallows is not yet understood, but it may simply be that these plants produce succulent flushes of leaves relatively early in the year–often as early as April. Another possible reason for their popularity is that sallows grow among many other shrubs and bushes, such as birch, hazel and hawthorn, which are used as foodplants by many species of moths. Most of the moths themselves are not particularly fussy as to which tree or bush they feed on, so they are just as likely to be found on sallows.

Regular residents Although the caterpillars of a large number of moths feed on sallows, none relies solely on these plants, but may also feed on other willows, poplars and even fruit trees. Despite these wide-ranging tastes, a few moths seem to favour sallow in preference to other willows. Among the better-known examples are the puss moth, sallow kitten, eyed hawk-moth and pebble prominent.

The caterpillars of the sallow kitten and puss moths are very distinctive, yet they are extremely difficult to see on a branch. Their similar bold markings of green and purple-brown help to break up their outline and constitute an example of disruptive camouflage. If caught out, they have a second line of defence which involves extruding red 'whips' from their twin 'tails', at the same time exposing red and black eye-like markings behind their head. As a final attempt at defence the caterpillars of the puss moth can eject a jet of formic acid from glands behind their head. The adult moths of both species are rarely seen as they rest during the daytime on tree trunks or under leaves. The eggs of the puss moth are quite large (2mm diameter) and brick-red; they can be found by searching the upper or lower leaf-surfaces of sallows in May or June.

The caterpillars of the eyed hawk-moth are also very difficult to see on sallow bushes because, despite being the size and thickness of our little finger, they blend into the background very well in their natural position

Below: The prominent bump on the caterpillar of the copper underwing is not to be confused with the thread-like horn of hawk-moth caterpillars.

under a twig or leaf.

By far the best way of finding these large caterpillars is to look for branches that have been stripped of leaves. This advice also applies when seeking the green caterpillars of the herald moth which rest along the mid-rib underneath the leaves of sallow. If discovered by predators they will jerk their bodies from the leaf and drop to the ground.

The pebble prominent is an attractive moth which uses willows, and sallows in particular, as larval food plants. Their caterpillars have characteristic bumps and fleshy outgrowths which give them a totally different shape to that of most other moth caterpillars. Other prominents which sometimes feed on sallows are the pale, swallow and coxcomb prominents.

Bristles and colour Some of the more conspicuous caterpillars found on sallows have vivid red, yellow or white colours and are usually adorned with tufts of stiff bristles. Among this group of sallow-feeding moths are the grey dagger, pale tussock, yellowtail and alder moths. None is specific to sallow and some definitely prefer other bushes. The caterpillars of these moths can afford to be conspicuous because they possess irritating hairs or bristles. The caterpillar of the pale tussock has long, thick tufts of yellow hairs along its back. If it is disturbed by a predator, these tufts splay open to reveal the dense velvety-black basal colour.

Sallow sticks Several moths with looper caterpillars are found on sallow. These include the peppered moth, brindled beauty, red underwing and clouded border. Their caterpillars bear an uncanny resemblance to twigs, complete with imperfections and scars. To find such well-disguised caterpillars on a sallow bush you must look for signs of their feeding, usually apparent as pieces missing from leaves, then carefully examine the branch around the damage. The adult moths are night fliers and during the daytime may be found among the herbage or on tree trunks, often some distance from sallows or other bushes.

Colonial caterpillars Perhaps the most obvious moth caterpillars that are found on sallows are those such as the lackey or buff-tip which feed in colonies, systematically denuding large areas of foliage. The lackey moth is particularly conspicuous because of the white silken webs its caterpillars spin and their habit of basking in clusters on the surface of the web. This habit is a way of reinforcing their unsuitability as food for birds. The caterpillars of both species have bright warning colours, patterned in black and yellow, while the lackey's are striped red, blue, white and brown. Among the other more obvious species you may expect to find on sallows are the green and black caterpillars of the emperor moth, and the green humped caterpillars of the copper underwing. Both produce equally pretty adult moths.

Sallow caterpillars

Above right: Some of the more common moth caterpillars you can find on sallow. You have to look carefully to see some of them.
1 Peppered moth (*Biston betularia*).
2 Herald moth (*Scoliopteryx libatrix*).
3 Red underwing (*Catacola nupta*).
4 Lackey moth (*Malacosoma neustria*).
5 Pebble prominent (*Eligmodonta ziczac*).
6 Eyed hawk-moth (*Smerinthus ocellata*).
7 Sallow kitten (*Harpyia furcula*).

Right: The adult herald moth is often found inside hollow trees or buildings, where it passes the winter. Once active in the spring the colour and shape of the moth disguise it as a dead leaf.

Below: One of the more common and colourful caterpillars on sallow is that of the yellowtail moth. The bright colours of this caterpillar warn birds that its bristles and hairs would irritate if eaten.

THE WORLD OF A SANDY BEACH

The beach is a product of weathering rock and the sea's drift. Countless molluscs and worms live inside the sand, while animals on its surface range from tiny sandhoppers to birds and seals.

Opposite left: Perran beach at Perranporth on the north coast of Cornwall.

Below: Sanderlings can sometimes be seen scurrying along the water's edge, stopping to probe the sand for food–sandeels and small buried invertebrates. Sanderlings are most likely to be seen from later summer through to spring, when they return to their breeding grounds in the Arctic Circle. The brown birds seen here are in their breeding plumage.

Sand consists of tiny particles of rock and shell, and is the result of years of erosion and weathering by the sea. The erosion begins with the sea gnawing away at cliffs and breaking off rocks and stones. These are carried away by the sea and waves batter them against rocky foreshores, breaking them and their attached shells into ever smaller pieces. Thus the sea produces the raw materials for a sandy beach.

The next stage in the creation of a sandy beach takes place once the particles of rock and shell are small enough to be suspended in the water, when they are carried along the coast by a process known as 'longshore drift'. The direction from which waves approach a stretch of coast is determined by the direction of the prevailing wind, since the waves are created by winds out at sea. As the waves hit the shore they run up the beach, usually obliquely (depending on the wind direction), carrying their cargo of sand with them. This is called the swash. The water returns (the backwash) by the line of least resistance, which is straight down the beach. By this to-and-fro action, wave after wave, the sand is shifted along, guided by the direction of the prevailing wind. This is longshore drift. If the swash is more powerful than the backwash then the sand gradually builds up to form a beach. If the backwash is dominant the sand moves on along the coast, round the headland, and perhaps the next, until it comes across a bay in which the conditions are right for the formation of a beach.

Beneath the surface Like all habitats dominated by the tides, sandy beaches have their favourable and unfavourable periods for the creatures that live there. The water brings a fresh source of food on each tide but when it retreats the inhabitants–invertebrates such as worms, crustaceans and molluscs–have to seek shelter against the sun, the wind and predators. For this reason the great majority live beneath the surface of the sand.

One of the most obvious inhabitants is the common lugworm, which advertises its presence with the familiar coiled worm casts. This worm lives permanently in a U-shaped burrow, where it swallows sand to extract the organic content, after which the sandy waste is ejected as the cast. A few inches away from the cast a shallow round depression in the sand marks the entrance to the worm's burrow.

where the feeding activities of the head end is causing the sand to sink. The only way you can see the worm itself is to dig for it (as anglers do for bait) or hope to see it being dragged out by an oystercatcher or a gull feeding at low water.

The damp sand of the inter-tidal region contains many different marine worms besides the lugworms. The tube-building worms are particularly satisfying to find because they build beautiful shelters against the difficult environment. The sand mason, for example, secretes a sticky mucus from its body, to which sand grains adhere. This sandy tube extends down into the sand and also pokes above the surface. When the tide is out the worm withdraws, leaving only the top of the tube open. As the tide comes in the worm extends itself up the tube to collect tiny food particles drifting past its waving tentacles. The tube provides the worm with a fixed home in the unstable medium of sand and allows the worm easy movement up and down in response to the changing rhythm of the tide.

Burrowing bivalves This kind of movement up and down in the sands in response to the tide is also performed by many different molluscs. The molluscs of the sand are mostly bivalves, in contrast to those of rocky shores which are mainly creatures such as limpets and winkles, which seal their single shells to the rock surface to keep in moisture and maintain an anchorage during the hazardous period of exposure. The bivalves have a different strategy to survive this dangerous period–they burrow, using a powerful 'foot' muscle to drag themselves out of sight into the damp sand.

A good example of a burrowing bivalve is the common cockle. When the tide is in the cockle lies half buried at the surface with its two shells slightly apart to allow its siphons to extend into the water for feeding and respiration. One siphon draws in water, along with its complement of plankton food, while the other siphon ejects the sieved water as waste. When the ebbing tide signals the end of the cockle's feeding time it tightly clamps its two shells, sealing itself in until the next flood tide, and hides itself just below the surface of the sand.

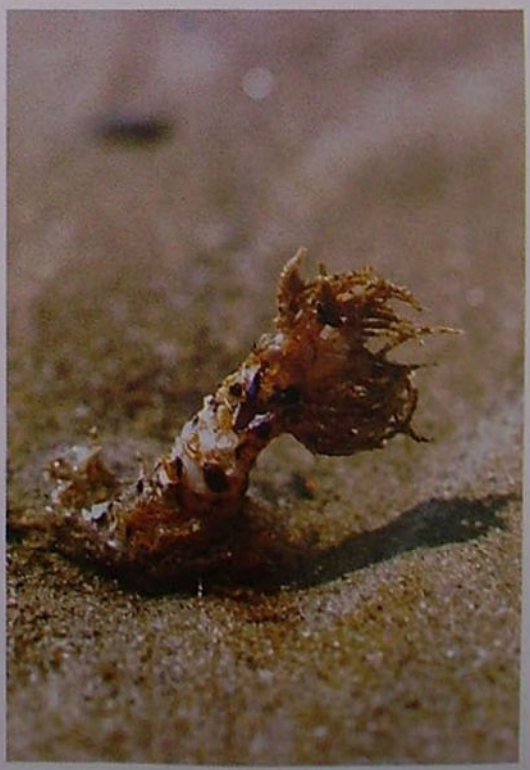
Hidden predators The sand also harbours some active hunters, such as the masked crab and the burrowing starfish. When the tide is in the masked crab digs and scoops its way into the sand with its powerful hind legs. Once hidden it breathes by drawing water down through long, tubed antennae and waits for the tide to go out so it can begin hunting. It is active only at night along the lower shore and shallow water, walking without the sideways scuttle typical of most crabs.

The burrowing starfish adopts a different strategy. It hides just below the surface of the sand and seizes whole molluscs or worms, swallowing them into its central stomach. A

Above: Oystercatchers waiting for the tide to go out so they can hunt for food in the shallow waters of low tide. They will be looking for creatures hidden in the sand, particularly bivalves such as cockles, which they break open with their powerful beaks.

Below right: A sand mason in shallow water with its tentacles out to pick up passing food particles. These creatures live inside a tube which they build by secreting a sticky mucus, to which grains of sands become attached, forming a protective 'pebble-dashed' sheath.

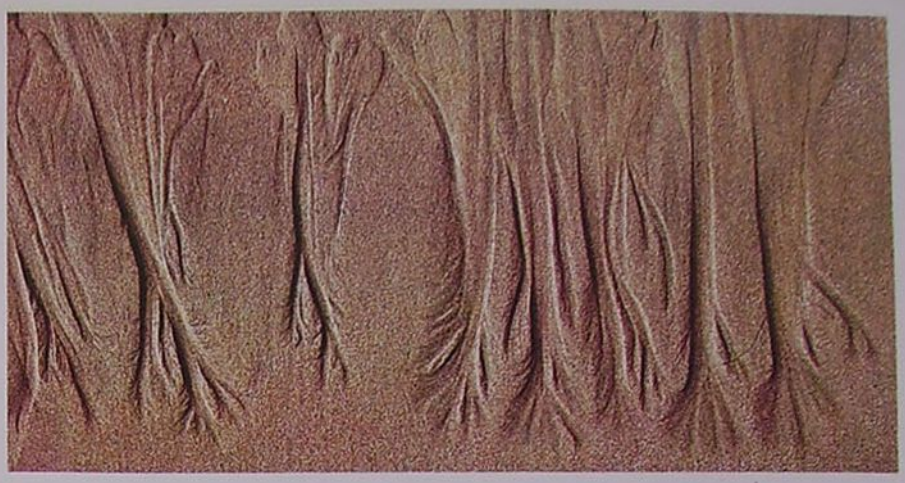
Below: Sea rocket is one of the few plants capable of growing on the shifting substrate of sand.



bivalve may seem indigestible, but the starfish has a way of dealing with it. Whenever the mollusc gapes, as it must periodically, the starfish's digestive juices reduce the meat inside to a ready meal. In due course the empty shell is rejected on to the surface of the sand.

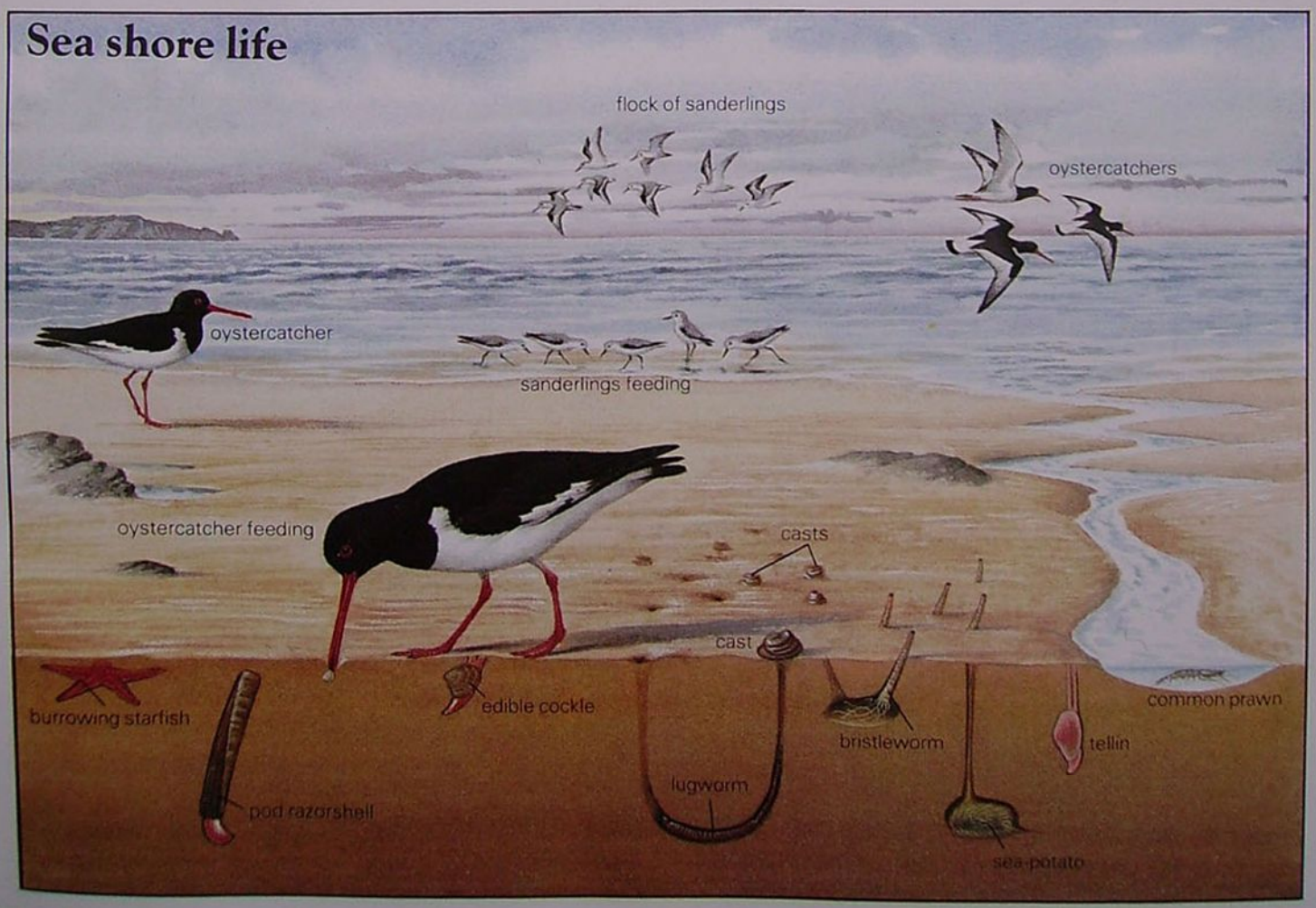
Birds on the beach Birds, too, are on the look out for molluscs, and they have some highly successful methods of extracting the meat from within the shells. Even the tough shell of a cockle is no protection against the powerful bill of an oystercatcher. Hunting in the shallows, just before the cockle runs out of feeding time on a falling tide, or before the incoming tide renders the water too deep for the bird to wade, the oystercatcher looks for an open-gaping shell. When it sees one it strikes the mollusc's adductor muscle, after which the mollusc is unable to close its shell in self-defence. Even if the shell does manage to close round the beak, the strong red bill can easily force it open again. Alternatively the oystercatcher can smash its way into the shell by using its beak like a hammer.

Gulls also use brute force when feeding on molluscs, but a certain amount of cunning as well. Herring gulls sometimes force cockles to the surface by paddling their feet up and down on the surface of the sand. They have also learned to pick up cockles from soft sand, fly with them until they are above a hard surface such as a rock or even a promenade, and then



Above: Patterns in the sand created by the receding tide. The slight depressions at the top of the picture are where the water has gouged out some sand as it flows back to the sea (from top to bottom of the picture). The sand is deposited a little further down to form these branching patterns.

Right: A sea-potato burrowing into the sand. This sea-urchin is capable of burrowing down as far as 20cm (8in).



drop them so that they smash open below.

Beach plants Sandy beaches do not exist in isolation but are flanked by rocky headlands or shallow rocky foreshores. In sheltered parts of the beach, where the water currents are slack, the sea often carries a large cargo of debris from these neighbouring habitats, and from further out at sea itself: seaweed, dead animals and shells, for instance. At the high water mark much of this organic material piles up to form the familiar strandline with its own wildlife of scavenging sandhoppers, kelp flies, turnstones, crows, rats and foxes. The same strandline also supports most of the few plants found on the lower reaches of a sandy beach. Here you may find plants such as saltwort, sea rocket and orache.

Further inland, above the high tide level, the most obvious sign of plant life is often sand dunes. These are an extension of the sandy beach, formed when onshore winds carry the sand inland. Once there maritime plants–notably marram grass–stabilise the sand to form semi-permanent dunes.

Offshore seals Going in the other direction, away from the land, low tides sometimes create temporary offshore islands which, because of their isolation, are excellent habitats for seals. Common seals often give birth to pups on such islands, even though the pups must be able to swim before the next tide comes in to engulf them.

Once in the water the baby swims with its mother and then both return–suckling on the sand bank or in the shallows–when the island reveals itself again. Common seals spend a lot of time out of the water, humping on to the sand in large social gatherings as well as to drop pups. Their passage along the sand is marked by the characteristic tracks created by their bodies and flippers. As the tide drops the seals move with it towards the water.

From the seals' point of view, one stretch of sand is as good as another for their purposes–their preference for offshore banks is a direct response to human disturbances, for on land people are their only major enemies, and people flock to beaches in their thousands for the recreation they offer so well.

Above: Around low tide sandy islands may suddenly appear offshore. Though they last for perhaps just a few hours before the tide returns, this is long enough for common seals to haul themselves on to the sand and deliver their pups. The young seals, however, must be able to swim by the time the tide returns.

Below: Empty shells on the beach may provide useful clues to the types of animals living beneath the surface.

WADING BIRDS: WORLD TRAVELLERS

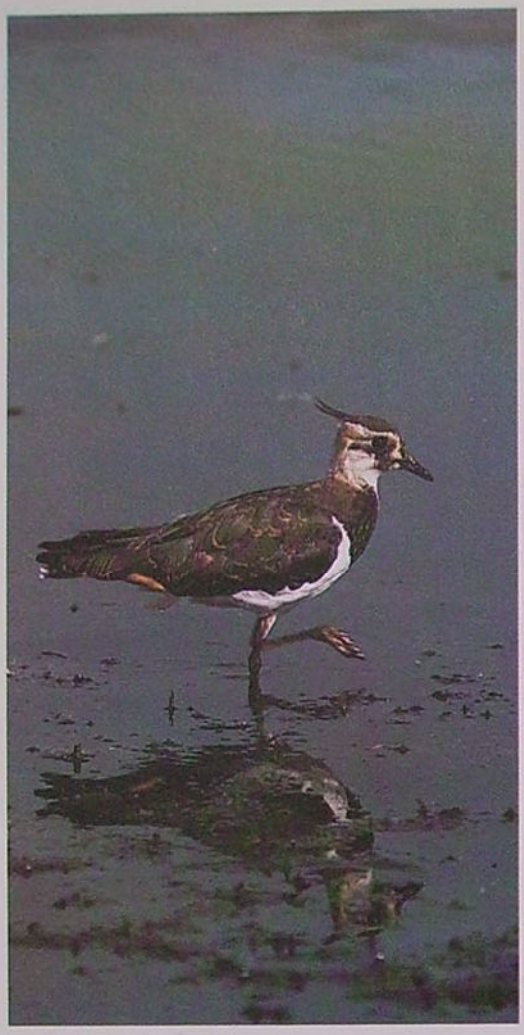
All waders breed in the Northern Hemisphere, and all are migratory, many crossing the equator for winter. The British Isles are sufficiently far north to be the breeding grounds of some waders, yet southerly enough to serve as wintering grounds for others.

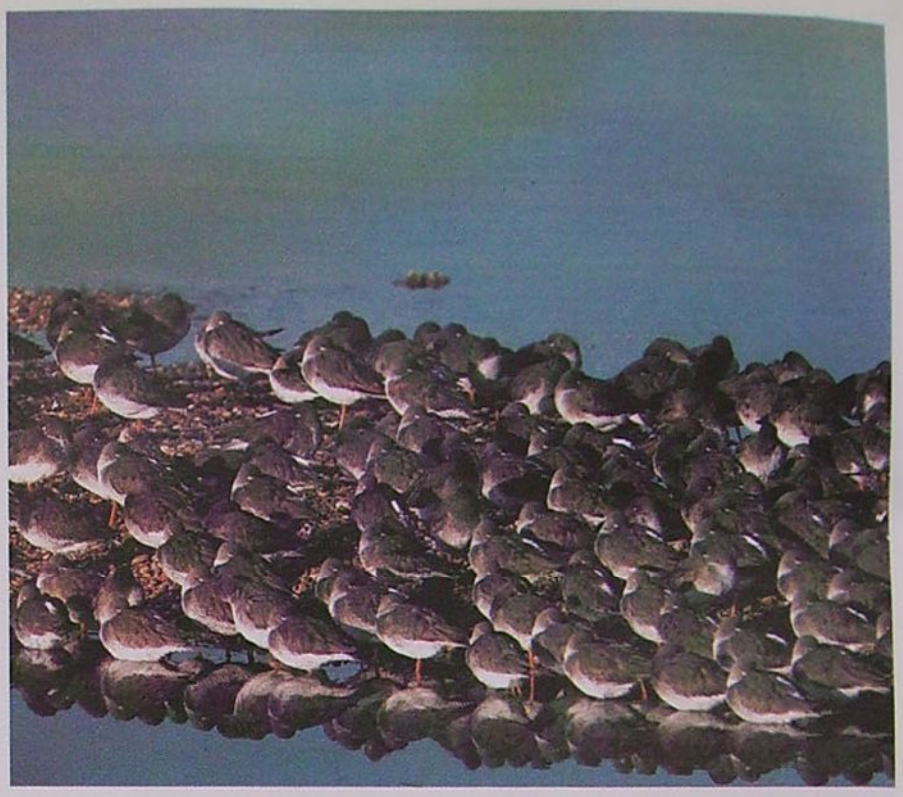
The waders form a major part of one of the most diverse of bird orders–the Charadriiformes or shore birds–which also includes gulls, skuas, terns and auks. About 60 species of waders have occurred at one time or another in Britain and Ireland, half of them being sufficiently common for the average birdwatcher to have every expectation of seeing them–winter or summer–without too much difficulty.

Above: In the last 50 years the curlew has extended its breeding range to lowland fields. In July curlews desert their breeding grounds in field, marsh or moorland, and make their way to the coast.

The main characteristics Waders are distributed among several different families within the shore bird order, but they have a number of general characteristics. All have long legs and long-toed feet relative to their size, and many have long slim wings, well adapted to fast and long-range flight. This is just as well, as perhaps more than any other group of species the waders exploit their powers of migration to the full. Of those occurring in western Europe, many winter as far south as the extreme tip of South Africa, and many (including most of these southern winterers) breed well north into the Arctic Circle.

Another widespread characteristic is that most waders in winter have extremely drab plumages. These are well suited to offer camouflage against the background of sheltered sandy or muddy coasts and estuaries, where the majority spend the winter. Exceptions to this generalisation include the





Above: A flock of redshanks roosting on a lagoon. Waders are not gregarious in the breeding season, but in winter they gather together like this. Few of our redshanks winter overseas, and those that do so travel no further than France.

Above left: In winter, most lapwings are found on wet grassland or ploughed fields. If snow or hard frost make feeding difficult, they then retreat to the coast.

Below: This young dotterel was photographed on an airfield in Cornwall. It was September, and the juvenile bird was on its first migration to wintering grounds in southern Europe–probably Spain or Portugal.

phalaropes, which winter out to sea; the rocky coast specialists like turnstone and purple sandpiper; and those that winter on damp meadows, often inland, like the lapwing and golden plover. The woodcock, as its name suggests, tends to frequent damp woodlands often far inland.

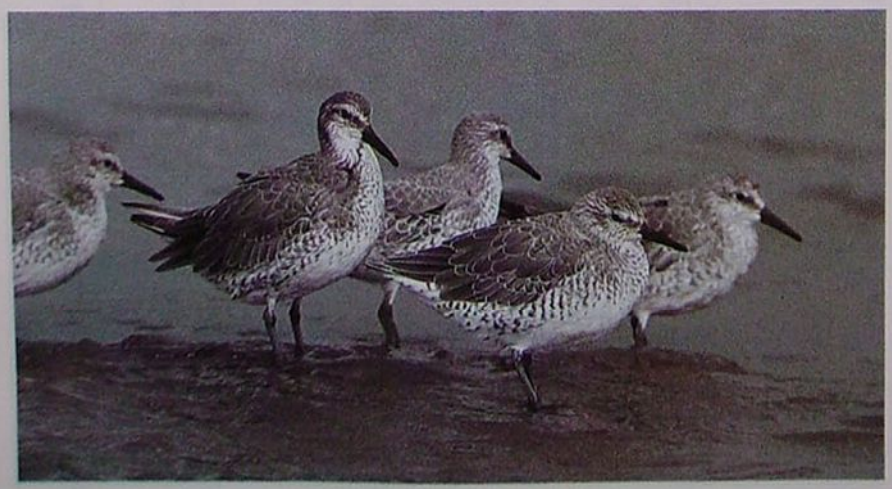
The main genera Many of the waders fall conveniently into broad sub-groups. Taking those with the longest bill first, the genera *Numenia* and *Limosa* contain the curlews and godwits, and *Scolopax* and *Gallinago* contain the woodcock and various snipes. Shorter-beaked are the shanks, mostly in the genus *Tringa*, while most of the sandpipers fall into *Calidris*. Those with the shortest beaks of all, and overall most uniform in structure, are the plovers; these form a very large group and are mostly apportioned to *Charadrius* and *Pluvialis*. Outside these main groups are a number of 'one-off' species: avocet, stilt, oystercatcher and stone curlew all come under this heading, while the phalaropes, though forming a small group of three species, do not fit in with any larger group.

Adaptations in winter Perhaps the winter months are the best in which to survey the range of feeding habits of the waders, and to see how each has a beak structurally adapted to its needs. Snipes and godwits have long, straight beaks, relatively robust and well suited to probing deep into the mud for worms and shellfish, but the curlew, with an even longer beak, can reach deep-burrowing food supplies. Many others have fine, medium-length beaks, perhaps best called 'general purpose'–suitable for entering shallow burrows and for picking small animals from seaweed or the water surface; the redshank is a good example. The avocet, with its unusual upturned, almost needle-fine beak, specialises in scything through water and fine mud for food.

On the mud, shorter-beaked waders like the dunlin and knot probe for shellfish and worms near the surface, while higher up on the beach, where the terrain is drier, ringed plovers scamper about seeking the small, non-burrowing animals which form their diet. One short-beaked, highly adapted bird is the turnstone, its beak flattened to a mini-shovel, with which it overturns stones and fronds of seaweed in its search for small invertebrates. Larger in scale is the oystercatcher, its beak stout enough to dislodge a limpet from the rocks but slender and sharp enough to snip through the adductor muscles that hold

Above: Hundreds of golden plovers taking off in a mass from a sheltered bay on the south coast of Ireland. This is a northerly species of wader, and although Britain and Ireland together hold some 400,000 golden plovers in winter, our southern coasts are about as far south as they are found.

Below: The knot is seen in Britain and Ireland only in winter; by April it is on its breeding grounds in the tundras of the high Arctic.



together the shells of bivalves such as cockles and mussels.

Summer plumage In summer a few waders retain drab plumage: the curlew for example, and the woodcock. In the latter case, the camouflage that the plumage provides retains its value in summer as well as in winter, as the woodcock is exceptional among waders in nesting among the bracken and fallen leaves of the woodland floor. Most of the others grow richly patterned and richly coloured summer plumage, in golds, blacks, browns and a wide range of russets. Some–grey and golden plovers for example–have bold black-and-white belly patterns. Here a compromise has been struck: the mottled rich russets offer astonishingly good camouflage against the tundra mosses and flowering plants, while the black breast pattern with its vivid white borders gives a brilliant impression in the territorial and pairing displays of the grey and golden plovers. Other waders lack any dramatic aspect of plumage for use in display, and these exploit some other attention-catching behaviour instead. The drab curlew uses its bubbling song flight as a conspicuous gesture.

Summer habitats During the breeding season, the majority of waders desert the shore line. In Britain, most depart for breeding grounds far to the north. Others, like the common sandpiper, arrive and establish breeding territories on fast-flowing rocky streams. The curlew, dunlin and golden plover move up into the hills, preferring high-altitude moorland on which to nest: the extreme example is the dotterel, nesting only on high, windswept mountain tops in the Scottish Highlands.

The lapwing, redshank and oystercatcher remain along lowland coasts and estuaries to breed, while on inland marshes other redshanks and snipe nest, with the occasional curlew, beside low-altitude marshes and bogs. The lapwing and oystercatcher breed on grazing marshes (as do the ruff and black-tailed godwit, both very rare as breeding birds in Britain), while some lapwings also often nest successfully in arable fields. In some, now

scattered, areas of high chalky farmland or arid heath, a few stone curlews come to breed each summer, their weird cries penetrating the darkness as effectively as owl hoots.

Wintering strategies For some of the waders that breed in the far north–dunlin, purple sandpiper and knot for example–the estuaries of Britain and Ireland may be as far south as they need to venture during the winter. For the rest of the northern breeders, the British Isles with their mild oceanic climate offer suitable wintering habitats for some birds, while others of the same species seek the safer refuge of the Mediterranean or North Africa. Examples of this type of behaviour are ringed plovers, many lapwings and oystercatchers, redshanks and greenshanks.

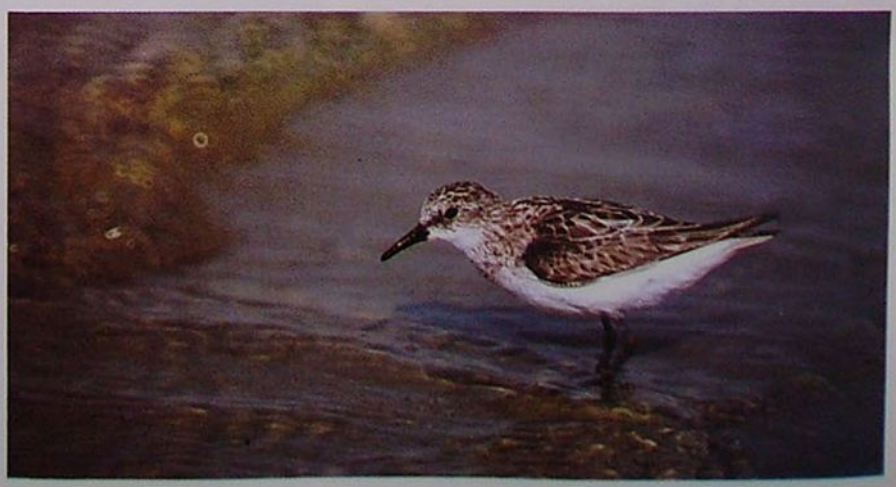
Yet other northern breeding waders perform really prodigious long-range migrations, though again, a few may remain to overwinter in the milder temperate areas: these include the curlew sandpiper (which rarely overwinters in Britain) and the sanderling (which often does). Long-range migrant waders head either for West Africa or, just as often, the extremes of South Africa.

Europe's stock of waders Of the approximately 60 species of waders in the world, half are common over much of Europe. The remainder are rarities, some native to Europe and some (vagrants) arriving accidently from other continents. Native rare species number about ten, and include such birds as the terek sandpiper from the Soviet Union and the broad-billed sandpiper from Scandinavia and the Soviet Union. The vagrants comprise about one third of the total list, amounting to some 20 species. Perhaps surprisingly, only three of these species originate from the eastern side of Europe, in Asia; at least 17 (the number increases almost annually) are North American species.

Most of these American wanderers occur in late autumn. Like all waders, they are powerful fliers, and it seems that most, migrating south on the other side of the Atlantic, are caught up in the fast-moving winds of depressions crossing the Atlantic from west to east.

Above: Black-tailed godwits on the Dee estuary in North Wales. Almost all of the black-tails wintering in Britain and Ireland belong to the Icelandic breeding population of the species. Conversely, almost all of our breeding population belongs to the Continental race.

Below: The little stint is seen only on passage: it breeds within the Arctic Circle, and winters in Mediterranean or tropical countries.



Checklist of British waders

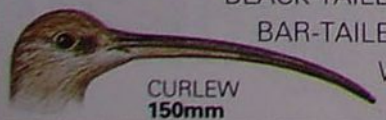
COMMON NAME	HABITAT		FOOD	
	WINTER	BREEDING SEASON	WINTER	BREEDING SEASON
DOTTEREL	—	mountain plateaux	—	insects, spiders
LITTLE RINGED PLOVER	—	gravel pits, river shingle	—	insects, spiders
RINGED PLOVER	coastal fields, mudflats	shingle and sandy shores	worms etc near surface	terrestrial and coastal invertebrates
GOLDEN PLOVER	farmland	upland moors	beetles, earthworms, plants	as winter
GREY PLOVER	estuaries, mudflats	—	worms etc near surface	—
LAPWING	farmland, coasts	moors, farmland	insects, worms etc on surface; plants	as winter
TURNSTONE	rocky shores	—	insects, crustaceans, molluscs	—
PURPLE SANDPIPER	rocky shores	—	insects, crustaceans, molluscs	—
KNOT	estuaries, mudflats	—	marine molluscs	—
SANDERLING	sandy shores	—	insects, crustaceans, molluscs in sand	—
LITTLE STINT†	lakes, coasts on passage	—	insects, worms etc on surface; plants	—
DUNLIN	estuaries, mudflats	upland moors	insects, crustaceans, molluscs, worms	as winter
RED-NECKED PHALAROPE	—	tussocky marshes	—	insects etc
GREY PHALAROPE	sea, lakes on passage	as winter	insects, crustaceans, molluscs, worms	as winter
COMMON SANDPIPER	—	river and lake shores	—	insects, spiders etc
GREEN SANDPIPER	wetlands on passage	as winter	insects, spiders, molluscs, fishes	—
WOOD SANDPIPER	wetlands on passage	as winter	insects, molluscs, worms	—
OYSTERCATCHER	sea and lake shores	as winter	molluscs, earthworms	as winter
CURLEW SANDPIPER	wetlands on passage	as winter	insects, crustaceans, molluscs, worms	as winter
RUFF	creeks and inland waters	damp grassland	insects, plants, seeds	as winter
STONE CURLEW	—	dry heaths	—	invertebrates on soil surface
SNIPE	inland marshes	marshes and moors	insects, crustaceans etc, frogs, plants	as winter
JACK SNIPE	inland marshes	—	insects, molluscs, worms, seeds	—
WOODCOCK	woodland	as winter	worms, insects, plants	as winter
GREENSHANK	mudflats, wetlands	upland moors	insects, crustaceans, worms etc, fishes	as winter
REDSHANK	estuaries, mudflats	damp grassland	insects, crustaceans, molluscs, worms	as winter
SPOTTED REDSHANK	mudflats, wetlands on passage	—	insects, crustaceans, molluscs, worms	—
AVOCET	mudflats, wetlands	brackish lagoons, marshes	sifts insects, crustaceans from water	as winter
BLACK-TAILED GODWIT	estuaries, mudflats	damp grassland	insects, worms, molluscs, seeds	insects, worms, molluscs
BAR-TAILED GODWIT	estuaries, mudflats	—	worms, crustaceans, molluscs	—
WHIMBREL	estuaries, mudflats	upland moors	molluscs, crustaceans	molluscs, worms, seeds, leaves
CURLEW	estuaries, mudflats	marshes, moors	worms, crustaceans, molluscs	insects etc, small vertebrates, seeds

RINGED PLOVER **12mm**

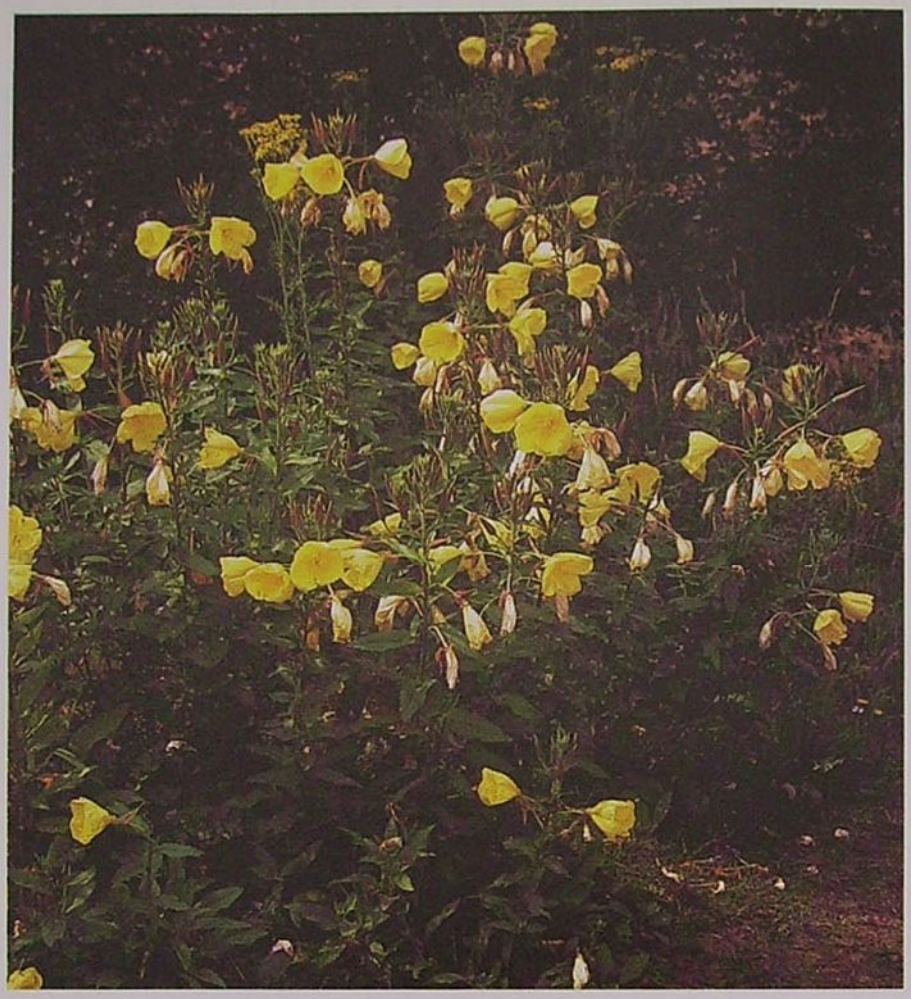
KNOT **26mm**

COMMON SANDPIPER **36mm**

SNIPE **66mm**



CURLEW **150mm**



PRIMROSES OF THE EVENING

At dusk the opening flowers of evening primroses produce a remarkable spectacle, for you can see the petals actually move. Once open the flowers have just a short time in which to become pollinated before the rising sun causes the petals to wilt.

At a time when dusk-flying moths begin their rounds, the conspicuous four-petalled flowers of the evening primroses (*Oenothera* species) start to open. Evening primroses are some of the best known nocturnal flowering plants in this country. Although common on waste ground, railway embankments and sand dunes the evening primroses found in Britain are not native but derive from North or South American plants. They are almost invariably yellow, but their flowers do not have such a soft colour as does the true primrose.

A common species One of the most frequently encountered species is the large-flowered evening primrose (*Oenothera erythrosepala*), an attractive garden plant that is now widely naturalised. It is probably of cultivated origin, having arisen spontaneously in Europe from originally introduced American parent species. It has since been introduced in the United States and has become naturalised there.

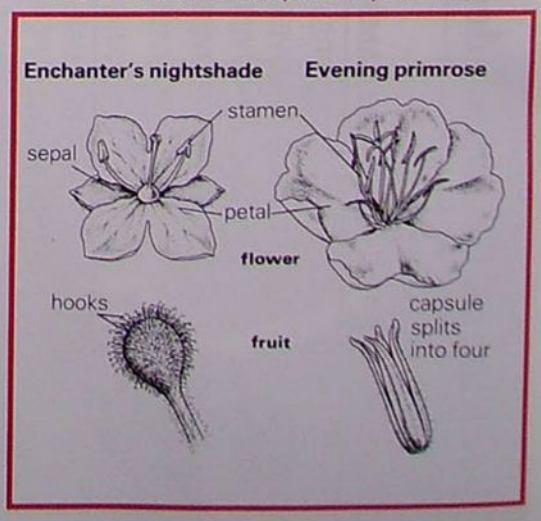
The large-flowered evening primrose is usually a robust herbaceous plant growing as high as 1.5m (5ft) with an upright, hairy, red-spotted stem. (These spots are the bulbous bases of the red hairs.) A biennial, this evening primrose survives the winter as a rosette of broadly elliptical or lance-shaped leaves with conspicuous white or pink midribs and attractively crinkled edges. Some plants grow from seed in the spring and, without reaching the proportions of the biennial plants or producing the basal rosette, flower later in the same year.

Evening spectacle Large-flowered evening primroses bloom in summer and autumn. In bud, the petals are enclosed in elongated, reddish sepals which have grown in such a way that, although separate at the base, they are quite firmly attached to one another towards the tips. As the day progresses, the petals, twisted and wrapped around each other in the bud, enlarge until the buds reach bursting point. When the evening draws nigh, one bud after another starts to split along the lines of weakness between the sepals. Once the split is complete, the sepals bend back on themselves quite rapidly leaving the petals free to unfurl.

Above: Large-flowered evening primroses, photographed just as the sun is rising and the petals are beginning to shrivel. This particular species has distinctive large petals, reddish sepals, crinkled leaves and red spotted stems. Although probably of cultivated origin, it is now widely naturalised throughout England and Wales, occurring on waste ground, railway embankments road sides and sand dunes.

Evening primrose family

Evening primroses belong to the family Onagraceae which also includes willowherbs and enchanter's nightshades. Typically the flowers of this family have four petals, four sepals and two groups of four stamens. An exception, though, are enchanter's nightshades whose flowers have only two petals, two sepals and two stamens. The fruits of evening primroses and willowherbs are many-seeded capsules which split into four, but the fruits of enchanter's nightshades have few seeds and remain closed; they possess hooks to aid their dispersal by animals.



You can actually watch the flowers opening, the entire process taking less than a minute. As the flowers burst open in quick succession, the whole plant seems to come alive with frantic activity. After about 15 to 20 minutes, there may be 50 or more flowers open on a moderately robust specimen and the air is filled with a powerful scent which attracts the moths.

The flowers have only a matter of hours in which to become pollinated, for as the sun rises the petals shrivel and fall. In a large number of species, the flowers are able to pollinate themselves without the intervention of insects.

The seeds are contained in a cylindrical capsule at the base of each flower which is initially red-spotted. As it ripens, it splits into four from the tip to the base, liberating large quantities of small, brown, sharply angled seeds.

Other evening blooms While large-flowered evening primrose appears on almost every rubbish tip and piece of waste ground its close relative, common evening primrose (*O. biennis*), is, despite its name, becoming progressively less common in Britain. Common evening primrose lacks the red-spotted stems and red sepals of its relative and the flowers are also less attractive with smaller petals.

The thick, white taproots of the common evening primrose used to be dug up in the winter and cleaned, scraped and cooked as a vegetable but other parts of the plant were avoided, for they contain distasteful chemicals. An oil prepared from evening primroses is being used increasingly for the treatment of hyperactivity in children and other nervous disorders.

Another species, the small-flowered evening primrose (*O. parviflora*), resembles the large-flowered species in many respects, for example its red-spotted stems, but the flowers have petals only 10-18mm long. In bud, a distinctive feature of this species is that the tips of the sepals spread outwards. Small-flowered evening primrose is naturalised on sand dunes, particularly in the south-west. The similar *Oenothera ammophelia* is less common and can be distinguished from the latter by its red-striped young fruit capsules and covering of white hairs on the leaves.

Pink primroses Other evening primrose species that occur in Britain include *O. grandiflora*, a large flowered plant popular in gardens and sometimes escaping into the wild. It differs from the large-flowered evening primrose in having straight-edged leaves and green stems; another distinguishing feature is its powerful scent which resembles orange blossom.

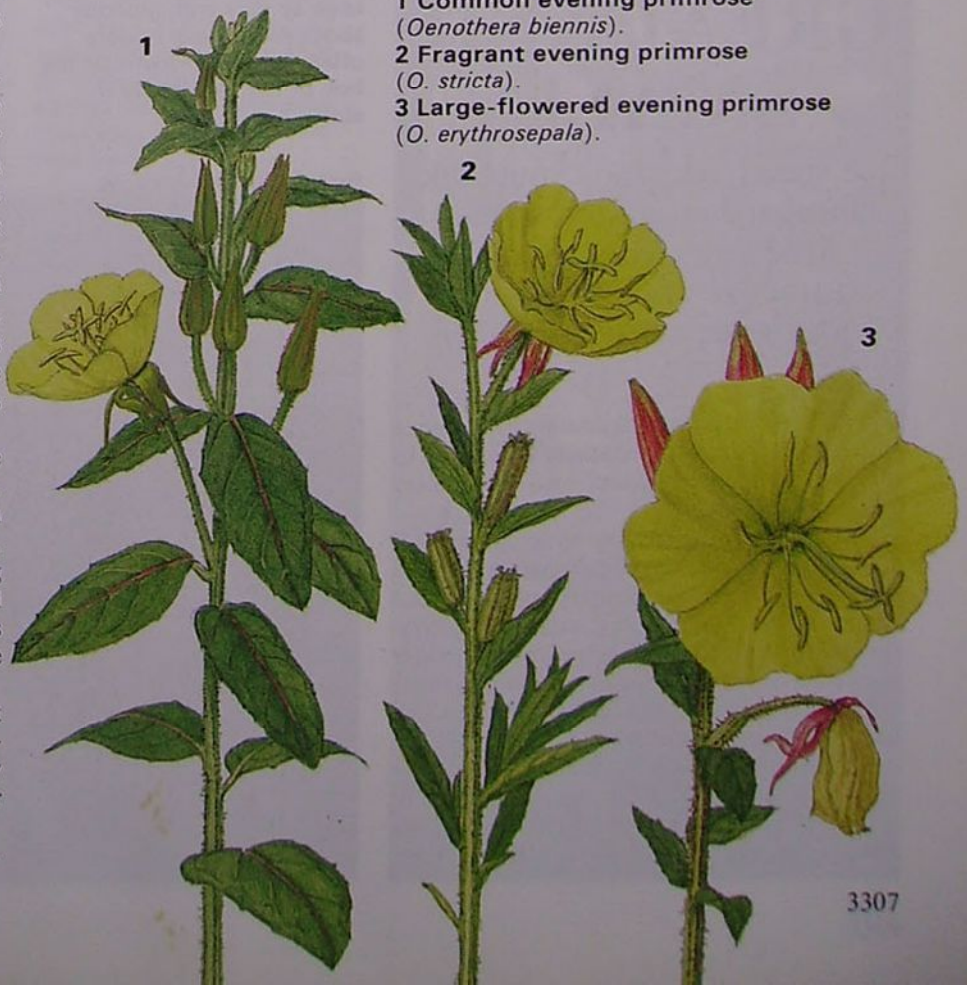
Fragrant evening primrose has flowers that are slightly smaller than those of *O. grandiflora* and easy to recognise because they turn from yellow to red. It is a rather slender looking plant with narrow leaves.

Another species with uncharacteristic flowers is the pink evening primrose (*O. rosea*). The flowers of this plant are pink or reddish violet and open in the early morning rather than at dusk. They are fairly small with petals only 4-10mm long. Sadly though it is only rarely encountered as a garden escape. In the wild the small flowers of pink evening primroses are pollinated by early rising bees such as bumble bees.

Above: Despite its popular name, common evening primrose (shown here) is much less widespread in Britain than large-flowered evening primrose. Its petals are also noticeably shorter, being only 2.5cm (1in) long as opposed to more than 3cm (1½in) long.

Three evening primroses

1 Common evening primrose (*Oenothera biennis*).
2 Fragrant evening primrose (*O. stricta*).
3 Large-flowered evening primrose (*O. erythrosepala*).



SPIDERS GREAT AND SMALL

One spider may look much like another but, armed with a little knowledge, many attractive and interesting species can be identified.

Above: Most orb-web spiders, such as this *Araneus diadematus*, are medium or large spiders with globular abdomens. These spiders often sit upside-down on the hub of the web, ready to strike.

Below: The evil-looking woodlouse spider can be found under stones or debris throughout Britain. This species is so-called because it feeds mainly on woodlice, despite their tough armoured casing.

In Britain we have approximately 630 species of spiders, which are grouped, according to behaviour and appearance, into 32 distinct families.

Spiders are very similar to a number of other creatures but can be distinguished from them by having four pairs of legs and combined head and thorax, called a cephalothorax. This last feature helps to tell a spider from a harvestman or mite because they have the cephalothorax fused to the abdomen and lack the 'waist' of spiders.

The most familiar feature of spiders is their ability to spin beautiful webs with which to trap prey. However, not all spiders do so. Many are ground dwellers who hunt by stealth and speed, usually at night when birds and other potential enemies are absent.

Web spinners The beautiful orb-web, a miracle of design and construction, enables the garden spider and others of the family Araneidae to catch a wide variety of flying and jumping insects. With strong, aggressive insects such as wasps, the spider demonstrates further skill by its 'attack-wrapping' method of quickly putting the prey out of action. As the wasp struggles to free itself from the stickiness of the web, the spider, acting on vibrations rather than sight, turns the wasp with its long legs while drawing multi-stranded silk from spinnerets to bind it in a tight cocoon. During the process it skilfully avoids the prey's sting. Depending on the species, other web spinners may bite the victim and move back and wait for the poison to take effect before attempting to feed on the prey. The webs of orb-spiders vary in such details as the number of radii (spokes of the web) and the type of hub (the central part of the web).

One of the most attractive orb-web weavers, for both the web and the spider itself, is *Araneus marmoreus pyramidatus*. This subspecies is so named because the yellow abdomen has a black, pyramid-shaped marking. The spider constructs its neat orb-web in waterside vegetation from July to September. Characteristically it waits among the support threads of the web without actually constructing a retreat.

Spiders in the house Most orb-webs are periodically rolled into a ball and eaten by the spider to recycle the protein. The spiders then spin a new one. The cobwebs of house spiders, *Tegenaria* species (family Agelenidae), are simply abandoned when they become too ragged and dusty. These large, brown and rather hairy spiders, are familiar, particularly in the autumn when the males leave their webs and search for mates– many end up trapped in baths. Take a close look at spiders of this family and you should spot a pair of long, flexible spinnerets at the end of the abdomen. *T. parietina*, the spider with the longest leg span in Britain (13cm/5in but body length only15mm), is a cobweb weaver and is known

Left: Typical of the family Theridiidae is the colourful spider *Enoplagnatha ovata*. This is usually white with red stripes and may be found on garden shrubs and weeds, such as the nettle shown here. This species has a small 'tangle web' of glue-studded threads which can trap insects as large as a bumble bee.

Below right: The female crab spider, *Misumena vatia*, may be white (as shown here) or yellow and can vary these basic colours to blend with its background. This spider has caught a honey bee which was visiting the flowers of common spotted orchid. The male crab spider is only half the size of the female and is found in the vegetation away from flowers.

Below: The raft spider (*Dolemedes fimbriatus*) is a semi-aquatic species that can walk upon the water surface, using the surface tension to support itself. It treats the water surface like a web, detecting vibrations and running to catch prey which land on it. If threatened it submerges and holds on to an underwater stem until danger passes, all the time breathing air from bubbles held by its hairy body.

as the cardinal spider, because Cardinal Wolsey was terrified of it at Hampton Court.

A spider with the tendency to occur in old buildings is *Pholcus phalangioides* (family Pholcidae). Also known as the daddy-long-legs spider, it has long delicate legs reminiscent of harvestmen but the body is quite different–long and rather tubular. *Pholcus* hangs upside-down in its 'scaffolding-web' of irregular threads in the corner of a room and reacts to disturbance by rapidly vibrating against the web to blur its outline.

Lace-webs Possibly the easiest web spiders to find, at any time of the year and throughout the country, are the 'lace-web' spinners of the family Amaurobiidae. These thick-set, medium-sized spiders have a characteristic black mark towards the front of the abdomen. On their fourth leg they have modified hairs which they use to comb out a bluish woolly silk from the spinnerets. The rather untidy silk mat which forms the web does not include sticky droplets but nevertheless is very effective in snagging the legs of crawling insects. A mature tree with fissured bark may have as many as a hundred of these webs issuing from crevices where the spider waits out of sight. The touch of a vibrating tuning-fork on the web often results in the sudden appearance of the spider.

Related to the lace-web spiders are a group of tiny spiders belonging to the family Linyphiidae, most of which are only 2-3mm long, and black or brown in colour. They are popularly known as money spiders. Most of them spin tiny webs on the ground which are usually only seen when heavily beaded with dew.

Hunters and stalkers When the sun comes out so do the sharp-eyed jumping spiders, family Salticidae. Probably the most common

species of jumping spider is *Salticus scenicus*. Also known as the zebra spider, because of its black and white coloration, this spider is found in early summer throughout Britain and Ireland on walls and fences.

By far the most familiar hunting spiders belong to the family Lycosidae, often called the wolf spiders. They are medium-sized spiders, usually brown and sometimes with strong patterns. All have good eyesight and long legs, which they use to chase and catch their insect prey. In summer the females become more noticeable, as they run with pale-coloured egg sacs attached to the tips of their bodies. Wolf spiders occur in open habitats and woods but are particularly abundant in grasslands. A common species in such a place throughout the country is *Alopecosa pulverulenta*, which has a white band on the head and thorax and contrasting black and yellow markings on the first pair of legs, particularly in the male.

Some spiders prefer to sit and wait rather than hunt, and none more so than the crab spiders belonging to the family Thomisidae. Most members of this family are rather squat and slow moving; the first two pairs of legs are longer and stronger than the last two and, like crabs, they can walk sideways. Many are coloured to match their background and some have different colour forms to match different flowers or plants.

Walking on water One of our most handsome spiders is the raft spider (*Dolomedes fimbriatus*) which is one of our three species in the family Pisauridae. *Dolomedes* is found in marshes and well vegetated ponds in the south of England.

Hunters of the night Emerging from daytime retreats and hiding places, the many night-hunting spiders are seldom seen. These belong to the families Dyseridae, Clubionidae and Gnaphosidae, and most are slim bodied, small to medium-sized spiders. Their eyesight is generally poor and thus hunt by stealth, rather like the woodlouse spider, *Dysdera crocata*. However, spiders do not have it all their own way. Among their many enemies are spider-eating spiders such as *Ero furcata* which belongs to the family Mimetidae. The four species in this family are all small–around 4mm–and move very slowly. With great care, these pirate spiders invade webs of other spiders and bite the leg of the owner, delivering a powerful and fast acting poison.

Thus we see that spiders, although often tiny, are none the less interesting. They are an important part of the ground fauna in many places, and trees, bushes and cliffs have their own characteristic species. If looked at more closely and without the revulsion which many people feel towards them, spiders are seen to be fascinating animals. Each has its own life style and specialisations which enable it to thrive in the variable British climate.

Above: The eight eyes of a jumping spider are arranged around the head, but only the front two are able to focus and judge distance. These spiders do not build webs; instead they stalk their prey before leaping once close enough.

Below left: A house spider presents an horrific sight when seen enlarged from the head end.

Below right: Wolf spiders such as this beautifully camouflaged *Arctosa perita* are sprinters with good eyesight. They are fond of basking on bare earth or dead leaves in spring and are the source of the tiny pattering feet you may hear over dead leaves.

Spider families in Britain

Spiders come in a wide range of colours, shapes and sizes, as shown here. They all share the common feature of four pairs of legs and a body divided into two parts.

Order: Araneae

Family	Common name	Number of species
Araneidae	Orb-web spiders	36
Agelenidae	Sheet-web spiders	22
Pholcidae	Daddy-long-legs spiders	2
Amaurobiidae	Mesh-web spiders	3
Theridiidae	Comb-footed spiders	49
Linyphiidae	Money spiders	250
Salticidae	Jumping spiders	33
Thomisidae	Crab spiders	38
Lycosidae	Wolf spiders	37
Pisauridae	Purse-web spiders	3
Dysderidae	Night hunting spiders	3
Clubionidae	Night hunting spiders	38
Gnaphosidae	Night hunting spiders	29
Mimetidae	Pirate spiders	3
Segestridae	Tube-weaving spiders	3
Others		71
	Total	620

Cheiracanthium erraticum
(Clubionidae)
7mm (¼ in) body length

Segestria senoculata
(Segestriidae)
8mm (¼ in) body length

Nuctenea umbratica
(Araneidae)
14mm (5/8 in) body length

Trochosa ruricola
(Lycosidae)
12mm (½ in) body length

Steatoda bipunctata
(Theridiidae)
6mm (¼ in) body length

Ero cambridgei
(Mimetidae)
7mm (¼ in) body length

Diaea dorsata
(Thomisidae)
3mm (⅛ in) body length

Evarcha arcuata
(Salticidae)
7mm (¼ in) body length

WILDLIFE OF A CHEMICAL WASTELAND

Natural colonization of a demolished chemical works site and its waste tips has produced one of the most remarkable wildlife habitats in north-west England. Sympathetic reclamation work by Greater Manchester Council has protected and enhanced its important plant communities and uncommon species.

Right: The common daisy: common it may be, but it is an early opportunist invader of abandoned areas. Like lesser knapweed, eyebright and devil's-bit scabious, this prolific and bright species does much to cheer up a wasteland.

About two miles from Bolton, on the edge of the Greater Manchester conurbation, is one of the richest wild orchid sites in north-west England. Within an area of about 4ha (10 acres) are huge colonies of several orchid species and hybrids, as well as an abundance of other unusual wild flowers. They are thriving on a site which less than a century ago was occupied by a chemical works that discharged huge quantities of toxic waste.

Chemical waste and orchids Numerous orchids are actually growing on the chemical waste whose toxic properties have been washed out by the rain. In some years researchers have calculated that there are an astonishing several hundred thousand orchids flowering on this one site. Fragrant orchids are the most prolific, but certain other species are almost as abundant: early and northern marsh orchids, and common spotted orchids, for example. Green-winged orchids have also been seen in recent years–they grow nowhere else in the county.

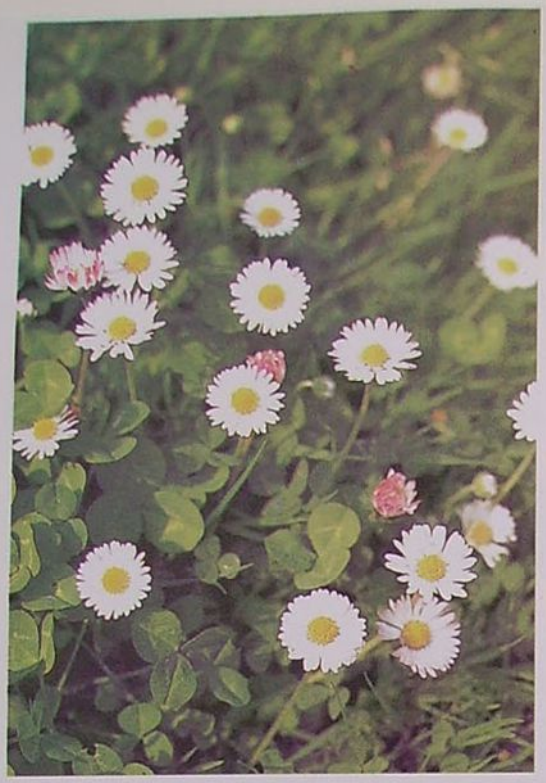
Many of the orchids are particularly large and vigorous with unusual variations in the shape and colour of the flowers. This occurs because of extensive hybridisation between the different species, particularly between fragrant and spotted orchids–two species well known to form hybrids.

Why do orchids grow so well in this waste? Many species like very base-rich or limy soils which are rather moist and not too fertile. The chemical waste provides these conditions exactly. It originated from the obsolete Leblanc process for the manufacture of sodium carbonate (washing soda) which thrived in the area until the early part of this century. Large quantities of waste were produced which were rich in lime.

Moreover the site that exists today as an ideal soil texture, being much lighter than most natural soils with good retention of moisture. Its particularly low nitrogen and phosphate contents do not promote dense colonization by grasses and other tall plants which would otherwise restrict the development and growth of the orchids. In many ways the conditions are similar to those of calcareous dune slacks of chalky soils, but the waste seems to be an even better medium for orchid growth than the most favourable natural soils.

Orchid origins Orchids do not grow in the

Above: This site on the outskirts of Bolton in Greater Manchester is surrounded by housing, mills, power stations and many kinds of industry. Less than 100 years ago it was occupied by a chemical works which polluted the environment, discharging large quantities of toxic chemical waste, especially lime. Yet despite signs of the prolific industrial activity of the past, today there is a variety of the most interesting and varied wildlife, particularly orchids.



Above: Among the strangest sights are yellow ant-hills due to the excavation of passages and chambers in the partially weathered chemical waste beneath the surface layer of newly formed soil. Yellow and white mole-hills have also been seen on some tips.

surrounding areas although some have been found recently on other industrial sites in the county, but these are of more recent origin. Were they introduced by man or did they arrive naturally? Limestone was certainly imported for the chemical process but its subsequent heating and chemical reactions would have killed any seeds present.

There seems little doubt that orchid seeds were blown in on the prevailing westerly winds from natural populations on the west coast of Lancashire, Merseyside or even North Wales. There are colonies of several species growing on the calcareous dune slacks at Formby, about 50km (30 miles) from Bolton, and others in North Wales. Orchids produce vast numbers of minute, extremely buoyant seeds which can be carried like dust for considerable distances over land.

The establishment of a single orchid plant is sufficient to initiate a large colony. On a similar but smaller chemical waste tip, not far from the site, a careful search in 1974 revealed a single fragrant orchid plant. Four years later a small colony had developed close to the original plant and there are now 2-3000 flowering plants with large numbers of seedlings. Observations of the Bolton site in the 1950s revealed just a few hundred fragrant orchids compared with up to a few hundred thousand plants there now. Their pattern of distribution also suggests that they have probably developed from an original single plant. It is not known how the mycorrhiza–the association between fungus and orchid plant necessary for the growth of orchids–originally became established in the area; this is one of the questions that is still being debated.

Threats to the wasteland In recent years the Bolton orchid site has been threatened several times. For a long while it has been regarded as derelict land and included with many other tips and contaminated sites requiring drastic reclamation treatment. Early in the 1970s there were tentative plans to reclaim it for agriculture by reshaping the landform and covering it with imported top soil. This would have completely destroyed its wildlife interest. Fortunately Lancashire County Council became aware of its biological importance and the site was retained in its existing state.

Below left: In July and August the ground is coloured pink by colonies of fragrant orchids which in some places are so densely distributed that up to 100 flower spikes can be found within a single square yard. Cowslips too (right) are beginning to form colonies and are spreading rapidly since they were introduced.

More recently still the plant communities have been damaged by motorcycle scrambling and cattle grazing. Several orchid colonies were partly obliterated by motorcyclists and a farmer on adjacent land grazed his cows on the site. Fortunately no manure or fertilisers were applied because the farmer did not own the land; recent experiments have shown that regular or heavy fertilisation would have been a disaster because it would have promoted grasses at the expense of orchids; most lime-loving plants, orchids included, cannot tolerate strong competition from other species.

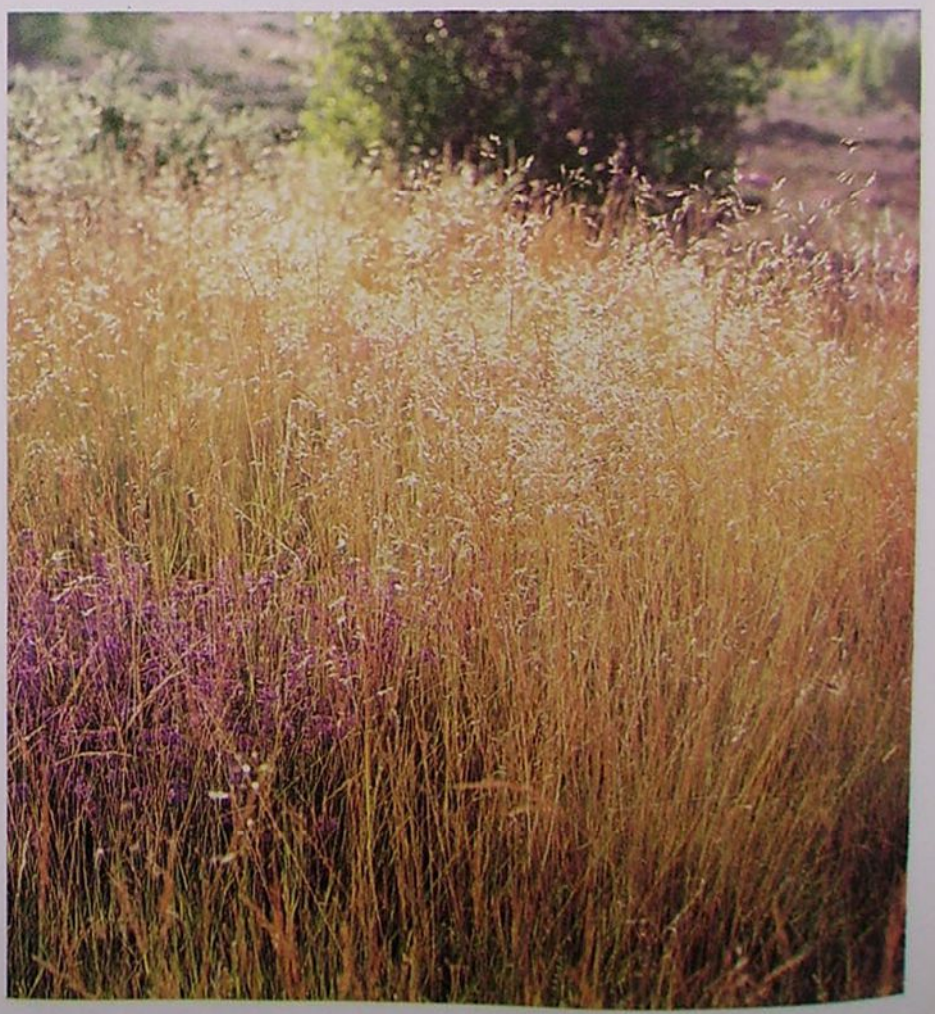
The land has now been bought by the Greater Manchester Council. Although included in the Council's reclamation programme, the restoration work has been carefully planned to protect and improve the flora and fauna. For example, strategically sited fencing and barriers have been erected to exclude cattle and motorcycles, but the public have free access to the site.

Sympathetic management The flora and fauna of the Bolton wasteland is at its best in late spring and early summer when there is a good show of colourful flowers, abundant insect life and many birds. During much of the year, however, the wasteland is rather drab and unattractive and looks to be in need of improvement. One way of overcoming this criticism, at the same time preserving the orchids and lime flora, is to enrich the plant communities with wild herbaceous plants, trees and shrubs. If planned carefully, this can extend the flowering period of the plant communities by including early spring and autumn flowers as well as producing a denser, more attractive plant cover. Trees and shrubs can add further variety to make the landscape more diverse and interesting.

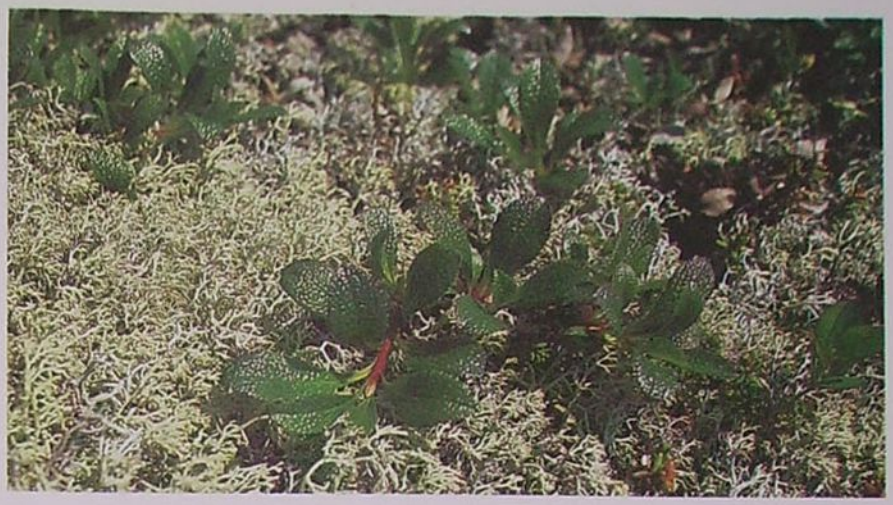
There are many chalk and limestone plants which are well adapted to the lime waste but cannot establish themselves because there are no local seed sources. A selection of such species has been experimentally transplanted or seeded into lime waste with remarkable success. Many are already forming colonies and spreading rapidly, making the flora much richer and more attractive. Notable successes are yellow-wort, yellow rattle, cowslip, primrose, kidney vetch, great burnet, rockrose and quaking grass. Even regionally uncommon plants which have been experimentally introduced have grown well, examples being marsh helleborine, bird's-eye primrose, twayblade, early purple orchid and blue sesleria grass. The range of possibilities is great.

Many botanists argue that introducing wild plants from other habitats is unethical for several reasons. For example, the introductions might spread too rapidly and disturb the balance of the existing flora. The natural distribution of species could also be affected.

However, there are powerful arguments in favour of this approach. One of the most



Above: Bird's-foot trefoil is one of the most colourful and abundant of the lime-loving plant species. Purging flax, centaury, blue fleabane, carline thistle and blue-eyed grass are uncommon in the region because of a shortage of suitable habitat, but they thrive on this particular wasteland site.



Above: Creeping willow, normally an uncommon species, and one of the smallest shrubs in the British Isles. It tends to grow in clumps, nestling close to the ground. Here on the Bolton site it is quite a prolific plant. Goat willow, sallow and willow hybrids grow here as well as shrubs such as hawthorn, and the rare Canadian hawthorn which is probably a garden escape and has attractive greyish, downy leaves.

Right: In addition to lime-loving species, particularly orchids like this northern marsh orchid, there is a thriving acidic flora containing just a few grasses and virtually no broad-leaved plants. Then, just a few feet further on, the flora changes back again to the species-rich lime communities. These acidic grassland patches, which are extensive in places, consist principally of wavy hair-grass (left) with localised mat-grass, sheep's sorrel, woodrushes and several ling or heather plants. They have sprung up where the lime waste is covered with thin layers of acidic boiler ash.

important is that many industrial and remnant natural habitats within or near the conurbations can only be protected if they are made more attractive or interesting to ordinary people as well as naturalists. Another reason is that nature has retreated from urban and industrial areas, leaving few local seed sources for recolonization. While plants such as rosebay willowherb and coltsfoot grow everywhere and can recolonize easily because of their effective seed dispersal mechanisms, most of the very attractive plants cannot reach new habitats.

Tree and shrub planting is, of course, well accepted. Whereas a few species such as hawthorn can colonize readily through effective natural dispersal mechanisms, there are attractive lime-loving shrubs which have no local seed sources: dogwood, wayfaring tree and spindle are good examples.

Another way of making the industrial flora more attractive is to encourage the spread of lime-loving plants on to the acidic and neutral parts of the site. Where there is species-poor and uninteresting acidic flora on boiler ash overlying lime waste, the ash can easily be removed. Alternatively ground limestone can be spread on the surface of the acidic boiler ash, as in normal agricultural liming but at much higher application rates. Field trials have shown that the lime-tolerant plants migrate naturally to the previously acidic or neutral areas after this is done. Orchids should do likewise, although they take longer to produce flowering plants.

Creative conservation Greater Manchester's policy of improving the environment involves bringing the countryside right into the conurbation. This depends on conserving semi-natural and industrial habitats and, just as important, actually creating new ones. The construction of habitats and the introduction of appropriate wild plants to them is an exciting new approach to nature conservation, and will become increasingly important as more semi-natural wildlife areas are lost. And unless other existing industrial habitats are protected, there will be few habitats left for wildlife in our towns and cities.

THE DEPTHS OF LOCH NESS

The Loch Ness & Morar Project, set up in response to reports of a Loch Ness monster, has discovered many surprising creatures living in the great depths of this loch, but no monster–yet!

Opposite left: Loch Ness was first investigated early this century by Sir John Murray and Fred Pullar, who discovered its true depth. After that the loch remained ignored until the 1960s when sightings were reported of a Loch Ness monster. The Loch Ness & Morar Project was one of several expeditions set up to investigate this phenomenon. Recently the Institute of Terrestrial Ecology has carried out an important pollution control survey there.

Loch Ness is by far the greatest volume of fresh water in the British Isles and, with a maximum depth of 230m (754ft), is second only to Loch Morar (310m/1017ft). It is up to 1.6km (1 mile) wide and stretches for 35km (25 miles) along the Great Glen south-westwards from its outlet at Inverness.

Loch Ness was created 300 million years ago when a tear in the earth's crust caused the northern part of what is now Scotland to slide past the southern part. As the two halves moved they separated slightly from each other and the land between them sank. The result was the formation of a steep-sided flat-bottomed valley, which was later to become Loch Ness.

With the coming of the Ice Ages, the rift valley was subjected to successive glaciations, and many of the species now present in Loch Ness are relicts from these colder times. At each glaciation, the weight of ice over Scotland forced the earth's crust downwards. When the ice later melted it raised the level of the sea sufficiently to flood some of the Scottish valleys, including the Great Glen, before the crust, relieved of its burden of ice, recovered some of its former altitude, raising the level of the area again. It seems unlikely that the sea has entered the Loch since the ice last retreated about 10,000 years ago.

An unproductive lake The biology of Loch Ness is governed by its great volume and depth. The productivity of any lake–the amount of life it can sustain–depends upon the quantity of nutrients washed into it from the surrounding soil and the amount of sunlight striking the lake and being available for photosynthesis. Loch Ness fares badly on both counts. The hard rocks of its steep catchment area yield few nutrients to the rivers and streams feeding the loch, and there is little arable farming in the area to increase the supply artificially by fertiliser run-off. The amount of sunlight is limited by the growing season being so short, since the Loch is so far north, and is restricted even further by the frequent cloud cover.

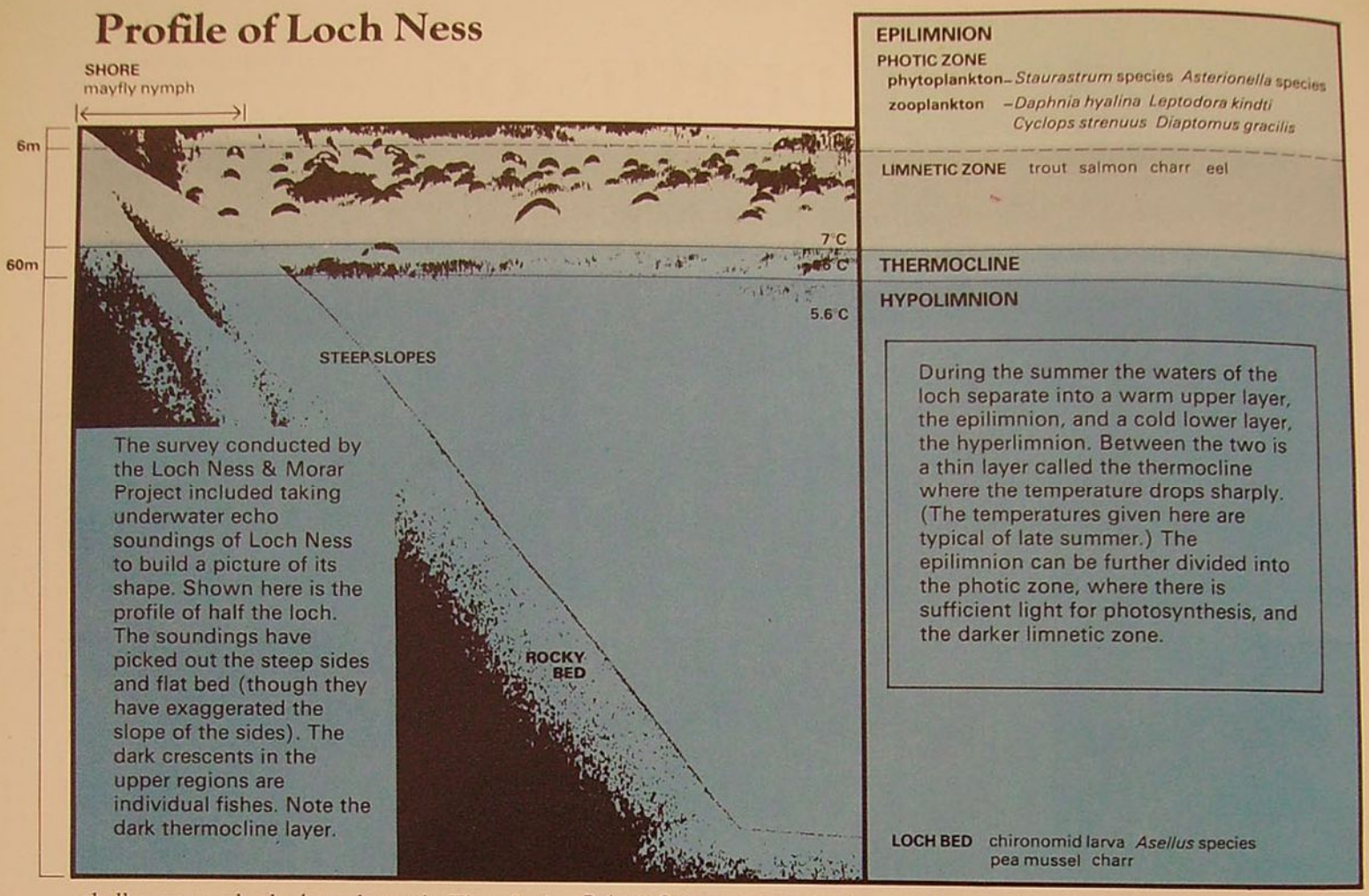
Loch Ness is, therefore, classified as being an oligotrophic lake–one that is poor in nutrients and incapable of sustaining very much life. By contrast, a eutrophic lake is one that has a high level of nutrients and a high productivity.

The shape of Loch Ness also has a bearing on its productivity. During the winter the water temperature is more or less uniform at 5.6°C (42.1°F), and it seldom falls below this. In June, however, the temperature at the surface of the water may be as high as 11°C (52°F), while 40m (130ft) below the temperature is around 7°C (45°F). The result is a layer of relatively warm water (called the epilimnion) floating on colder, denser water (the hypolimnion). Between the two there is often a zone where the temperature drops sharply. This is called the thermocline and it acts as a barrier, separating the two masses of water and preventing nutrients utilised in the upper layer being replaced by those from lower down. Come the winter, as the temperatures of the two layers equalise the thermocline layer disappears, and the nutrients in the different layers can mix.

Microscopic plants The lack of nutrients and sunlight places a severe restriction on the quantity of microscopic plants (the phytoplankton) present. Photosynthesis is limited to about the top 6m (20ft) of the water since below this depth the sunlight is too weak for photosynthesis to occur, due to suspensions of peat in the water. The peat also causes the water to be acid, which discourages the presence of blue-green algae. Among the green algae found in the loch are single-celled diatoms and desmids. Diatoms are much more common in a eutrophic lake; the desmids are more typical of nutrient-poor lakes.

Microscopic animals Dependent upon the phytoplankton are the zooplankton–microscopic animals. At Loch Ness the zooplankton are almost all crustaceans. There are two orders: the Cladocera and the Copepoda. The Cladocera can be further divided into two groups, Calypterma and Gymnomera. Calyptera have their body and limbs enclosed within a hingeless shell and swim with their antennae. They use their legs to draw water inside the shell, where they filter out food particles. In the Gymnomera the

Profile of Loch Ness



The survey conducted by the Loch Ness & Morar Project included taking underwater echo soundings of Loch Ness to build a picture of its shape. Shown here is the profile of half the loch. The soundings have picked out the steep sides and flat bed (though they have exaggerated the slope of the sides). The dark crescents in the upper regions are individual fishes. Note the dark thermocline layer.

During the summer the waters of the loch separate into a warm upper layer, the epilimnion, and a cold lower layer, the hyperlimnion. Between the two is a thin layer called the thermocline where the temperature drops sharply. (The temperatures given here are typical of late summer.) The epilimnion can be further divided into the photic zone, where there is sufficient light for photosynthesis, and the darker limnetic zone.

shell covers only the brood pouch. They feed upon the herbivorous zooplankton.

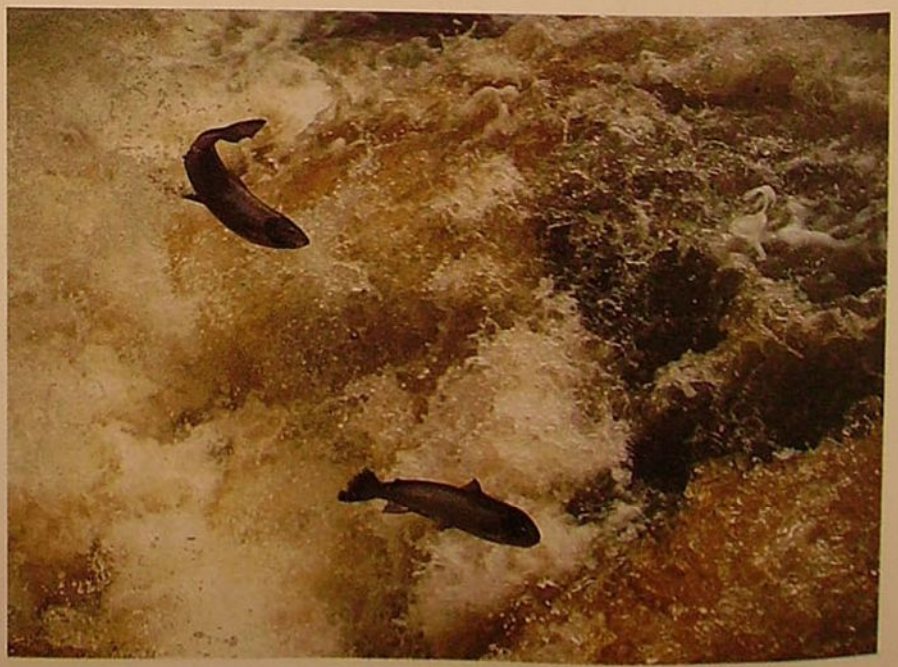
Copepods are pear-shaped creatures without shells. They use their antennae and their legs as swimming limbs. There are two groups: the cyclopids and the calanoids. The former carry their eggs in two sacs at the tail; fertilisation occurs via a spermatophore attached by the male. They feed on food particles in the water, though larger ones than those eaten by filter feeders. The calanoids carry a single egg sac and are filter feeders.

In general, the zooplankton of Loch Ness are transparent to avoid predators. They cope with the low nutrient levels of the lake by remaining relatively small and by producing fewer but larger eggs than their counterparts in more productive waters. Some species produce resting eggs that survive the winter and then hatch in the spring.

Shore life The steepness of the shore, and the waves breaking along it, create problems for animals living there similar to those encountered in fast-flowing streams. The nymphs of mayflies and stoneflies, which both live among shingle stones, overcome this problem by having grasping claws to hold on to the stones, and by having flattened bodies to reduce the impact of the water flow. These nymphs are very similar to each other except that stonefly nymphs have two tail filaments and mayfly nymphs three.

Fishes in the loch Most fishes in Loch Ness belong to the salmon group. Some are resident throughout most of their lives, while others are migratory, spending their adult lives at sea and entering the loch only to breed. Among the coarse fishes, only pike and sticklebacks occur in the loch.

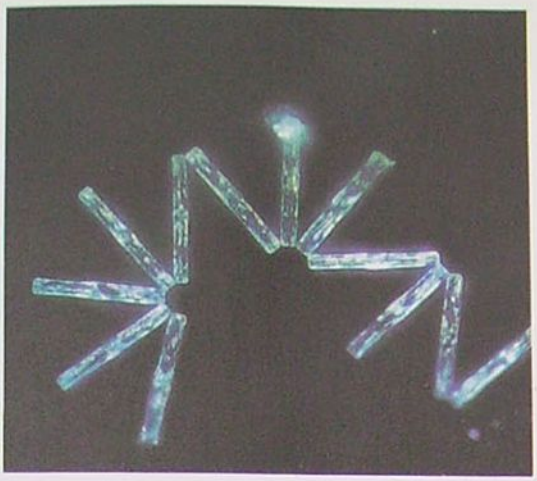
The dominant fish of the shallow water is the brown trout. Small specimens feed on the zooplankton and on shoreline creatures, though in the summer a large proportion of



Below: Salmon spawn in the feeder streams of the loch. After 2-3 years the young head for the sea, returning up to five years later to spawn and complete the cycle. Thus the largest fishes in the loch owe their size to the sea, not the loch–a fact highly pertinent to the possibility of a monster.

1 *Asterionella* is a diatom–a single-celled green alga. It floats near the surface where it can obtain enough light for photosynthesis. Individual plants sometimes pack together in rafts, and sometimes (as shown) form radiating groups. Length: microscopic.

2 *Mayfly nymph* lives under gravel on the shore, near the water's edge, slowly developing into an adult. Length: 10mm.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3 *Holopedium* is a member of the zooplankton found in the upper levels of the water. Its body is embedded in a mass of transparent jelly, which it secretes itself. Length: microscopic.

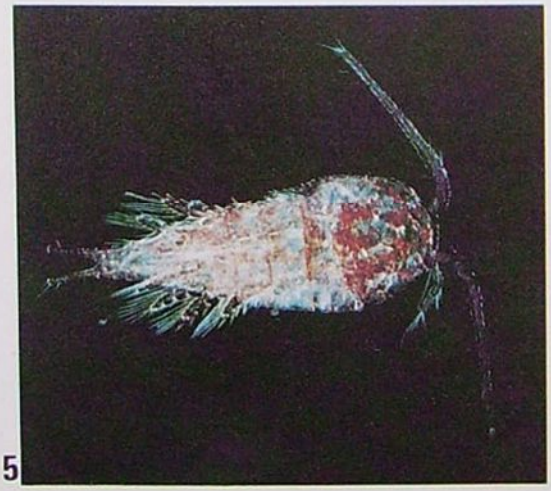
4 *Daphnia hyalina*, another member of the zooplankton, belongs to the order Cladocera. Its body and legs are encased in a rigid shell and it swims with its two long antennae. Length: 1-2mm.


3


4

5 *Cyclops strenuus abyssorum* is a copepod, one of the groups of animals found in the zooplankton. Copepods have distinctive pear-shaped bodies and their legs are free for swimming. Length: 1-1.5mm.

6 *Leptodora kindti* is the largest member of the zooplankton. It belongs to the order Cladocera and is a predator, feeding on herbivorous zooplankton. Length: up to 10mm.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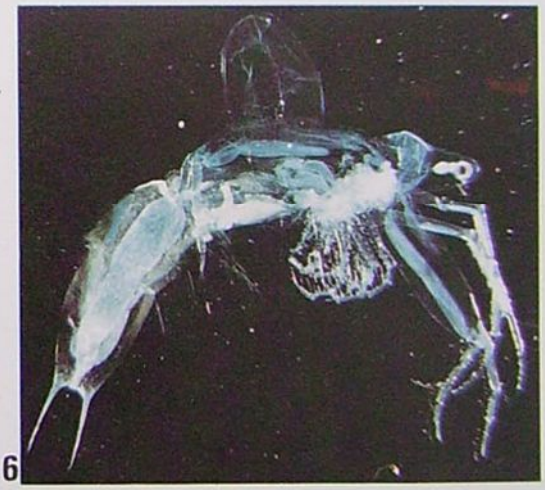
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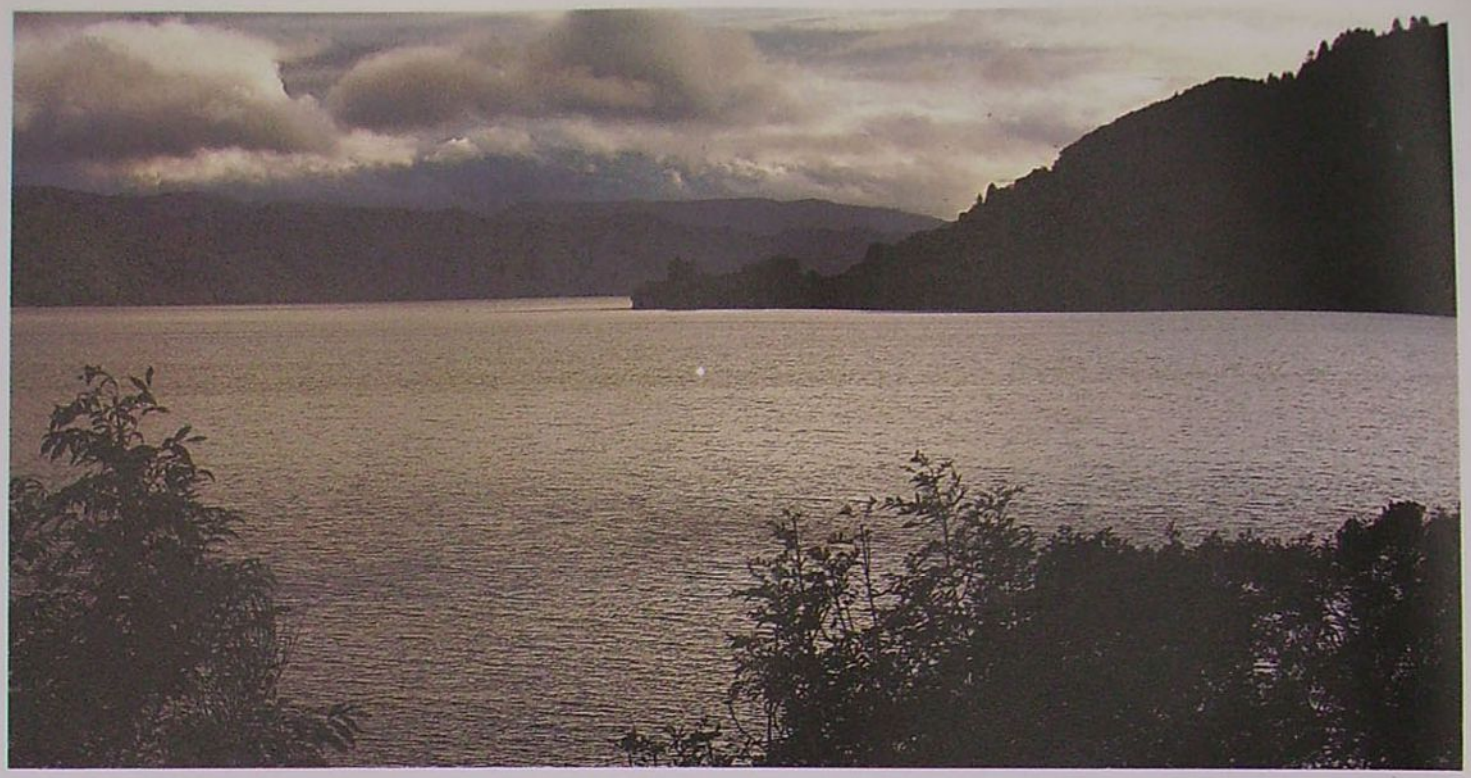
7 *Ostracods* are crustaceans which look like tiny silver beans. Their body and limbs are enclosed in a hinged shell, which can open allowing the limbs to protrude. Ostracods are found on the surface of the loch bed. Length: microscopic.

8 *Procladius* is a predatory chironomid, the larvae and pupae of which live on the loch bed. Shown here is the adult emerging from the pupal case. Length: 10mm.


7


8



their food comes from insects falling into the water. Larger trout (they may run to more than 5kg/11lb) take smaller fishes and are known as cannibal trout. The deeper water is the domain of the alpine charr.

Creatures of the deep Although the upper layers of an oligotrophic lake such as Loch Ness are poorer than the upper layers of a eutrophic lake, in the lower layers the reverse is often the case. In a eutrophic lake the high levels of nutrients in the water, combined with plenty of sunlight, can cause the plankton population to expand dramatically. When the plankton die the resulting organic matter falls to the bottom of the lake and decays, a process that consumes oxygen, which means there is less oxygen available for the animals living at the bottom. In an oligotrophic lake, on the other hand, the lack of nutrients in the upper levels prevents any build-up of plankton, and therefore any subsequent possibility of the oxygen level being reduced in the lower layers. Equally important, the sheer volume of water in the hypolimnion means it would take a great deal to deoxygenate it.

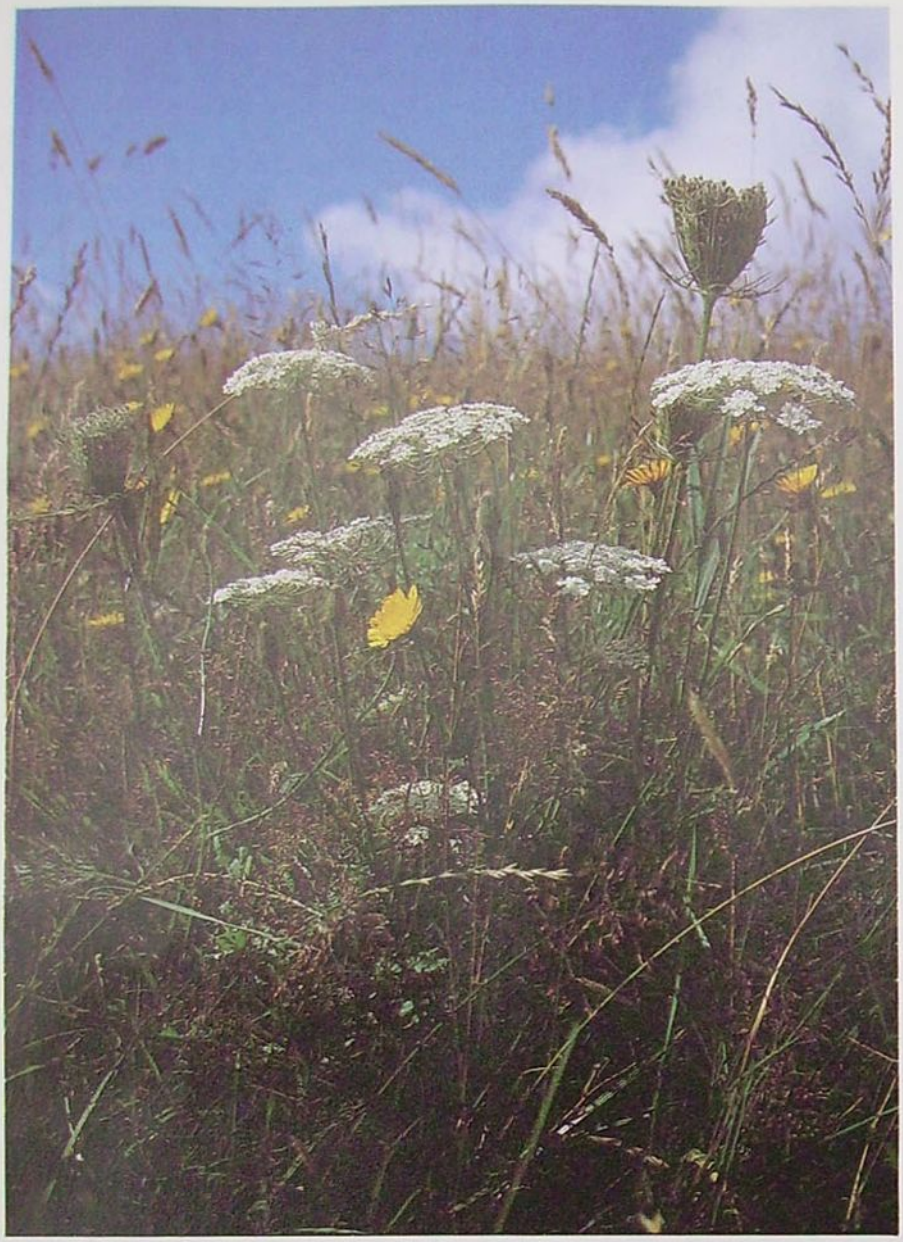
The Loch Ness & Morar Project was set up in the 1970s to investigate Scotland's two deepest lochs. By sampling the life present in the deep water of Loch Ness it has discovered that high oxygen levels have allowed life to extend down to the silt of the loch bed at depths of 200m (650ft) and more. Here is a community of animals in a stable world of great pressure (20 times atmospheric pressure), unchanging low temperature (5.6°C/42.1°F) and constant darkness. Many animals down here are relicts from the last Ice Age. An example is a species of pea mussel, *Pisidium convectus*, a tiny bivalve mollusc that feeds by filtering out particles from water.

The insect world has also penetrated to these depths. Larvae of chironomid midges have been found–some, called bloodworms, contain haemoglobin to store oxygen in times of deficiency. This ability is not required, however, in the reasonably oxygen-rich waters at the bottom of Loch Ness. How the midge pupae succeed in reaching the surface of the loch to emerge as adults through a water column greater than the height of the London Post Office Tower remains a mystery.

Fishes have also been observed on the loch bed. The Loch Ness & Morar Project first achieved this in 1981 by using an underwater camera, though it was not until a year later that three charr were actually taken, at a depth of 220m (720ft). Charr are known to feed on bottom-dwelling creatures when their usual food, zooplankton, becomes scarce so, bearing in mind the level of oxygen at the bottom, their presence is not surprising. It is of interest, however, that the fishes contained zooplankton in their intestines, indicating that they had made a fairly rapid descent from the upper waters.

Above: A view over Loch Ness from near Drumnadrochit, which lies on the main road running south-west from Inverness along the northern bank of the loch. Urqhart Castle can be seen on the promontory in the middle of the picture.

Below: A young charr. The charr population of the loch is a relict from the last Ice Age and occurs at depths down to 30m (100ft) or more. Exceptionally strong sonar contacts by the Loch Ness & Morar Project seem to indicate predators, probably fishes, moving within the lower levels of the charr population. The Project is seeking to establish whether these fishes are larger than the cannibal trout.



INSECTS IN THE MICRO JUNGLE

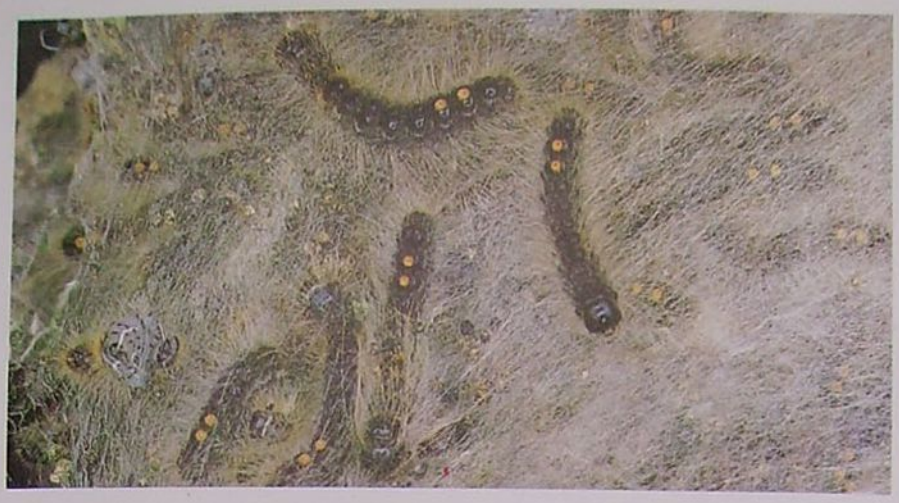
The vegetation on the ground is a jungle in miniature, where insect life is adapted to a range of sharply contrasting microclimates.

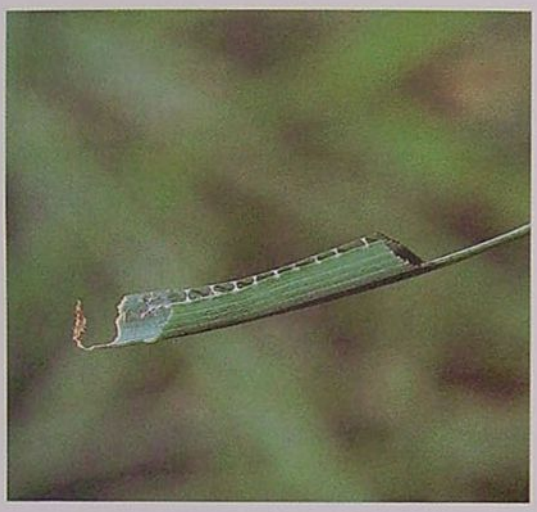
The world which we, as human beings, know is totally different from that in which insects live. Our height and upright stance influence our definition of the terms weather and climate. The daily temperatures in our weather reports are recorded in a standard enclosure set 1.3m (4ft) above mown grass. If we measured the daily temperatures at a height of a thousand metres above the ground we would naturally expect the results to be completely different. Yet we give little thought to the climate beneath our feet–on, under or slightly above, the ground.

An insect's view The term climate refers here to the overall range of temperature, humidity and wind speed in a particular environment. To an insect, the most important of these components are temperature and humidity. Insects are cold-blooded creatures, and the surrounding temperature completely controls their body temperature, which in turn determines their level of activity. Their small size means that they have a large surface area for their volume, and this makes them sensitive not only to temperature changes, but to changes in humidity as well. In dry conditions, water balance would be a serious problem for insects–they would quickly dry out if it was not for their waterproof armour. In describing creatures as small as insects, we refer to the places in which they live or pass through as microhabitats, each of which has its own microclimate. Here we look at those microhabitats and microclimates that occur at or near ground level.

The jungle and its layers The ground vegetation in a field of pasture, a lawn or a woodland clearing forms a tangle of stems, roots and leaves, rather like a dense jungle in miniature. This vegetation, like that of a real jungle or temperate woodland, has distinct

Above: An unmown pasture is a thick tangle of plants–a microjungle. Among the countless insects of the microjungle are tiger beetles (right) and gorse shield bugs, shown hatching as nymphs (below).





Above: The microjungle is a place of unreliably fluctuating temperature and humidity. To keep warm, these brown-tail moth caterpillars bask on a web that they spin collectively.

Left: To avoid drying out, the caterpillar of the large skipper butterfly sews a grass leaf into a neat hiding-place.

Below: The soil has a very stable microclimate, suitable for a pupa of the death's-head hawk-moth.

layers. The lowest is the surface of the soil, where roots become stems and moisture is always evaporating from the soil. The next layer is the lower parts of plant stems and leaves, where the light is distinctly green, having been filtered through leaves. The top layer is the growing tips of grasses and plants, where the flowers and fruits appear and the sun has a direct effect.

These vegetation layers are situated in the lowest part of the atmosphere, the half metre of air that acts as a buffer between the soil below and the atmosphere above. Within this height, the microjungle can contain a number of different microclimates. The lowest layer, for example, has virtually no air movement, while the upper section of vegetation is full of quivering leaves and eddies of warm and cold air.

The insects associated with the microjungle show a similar stratification. The lowest level is occupied by springtails and other minute insects such as proturans and diplurans. The larger, more familiar insects such as bees and hoverflies are seen on or above the flower level.

The basement Underlying the microjungle is an important environment for small animals–the soil. Consisting of a mixture of tiny rock grains and plant and animal matter, the soil is a home to a special community of insects. The microclimate here is attractive for two main reasons: plenty of moisture is held between the grains of rock, and the temperature range of soil is very small. Indeed, the further into the soil one goes the smaller the fluctuation, until at 60cm (2ft) or so the temperature is constant throughout the year.

Most soil insects are in their larval state, their dispersive adult stages occurring above ground. Soil larvae include those of many species of beetles and flies: particularly common are ground beetle larvae. On the other hand there are certain insects, such as sawflies or moths, whose larvae live above ground and come down into the soil in order to pupate. A few species in turn, such as earwigs and burying beetles, enter the soil as adults to construct underground nests.

Temperatures extremes The microclimate

Loss of microclimate

Once we have understood the significance of microclimates for insect life, we can explain some of the mysterious extinctions of insects in the past few years. Research on chalk downland has shown that the removal of grazing livestock, and the death of many of our rabbits through myxomatosis, has led to an increase in the turf height on many downland sites. This in turn has affected the microclimate of these sites and meant a change in the species of insect found there. The best-documented example so far is the loss of an inconspicuous ant called *Myrmica* (right) from many hillsides in southern England, where it was host to caterpillars of the large blue butterfly. The relaxation of grazing pressure and other factors led to longer turf, which in turn reduced the ground temperature. Under such conditions the *Myrmica* ant was replaced by other species which worked more efficiently at the new lower temperatures, but were unsuitable as hosts for the large blue caterpillar. The loss of the warm microclimate had the irrevocable effect of causing the extinction of the large blue butterfly.

of ground layers often involves greater extremes than the climate affecting humans. Insects in the microjungle can experience huge fluctuations in daily temperature, of a magnitude that larger animals–and we–experience only in deserts. On a summer's day in Britain, the sun's rays can warm the ground vegetation and the soil to temperatures of up to 50°C (122°F).

At night, especially when there is a clear sky, the same vegetation and soil radiate the heat back into space, thereby cooling considerably. As the plants and soil cool, some heat flows into them from the deeper soil layers, but nevertheless the temperatures of plant and soil surfaces may fall to freezing point by sunrise. As well as radiative heat loss, low-lying places may experience extra cooling because of cold air collecting at the soil surface, displacing warmer air and causing a frost, even in summer.

For insects, this is one of the worst hazards of the microclimate on the ground: certainly, if temperatures exceed the range of around 0°-50°C (32°-122°F), they will quickly die unless they are capable of entering special resistant forms.

Basking insects For every species of insect, there is a particular temperature at which it becomes active, and a higher temperature at which it reaches peak efficiency. Tiger beetles, for example, become active at around 18°C (64°F), while sand wasps wait until they have a body temperature approaching 26°C (79°F). Basking is the commonest form of behaviour insects adopt to gain body warmth.

Many butterflies take advantage of sunshine by opening their wings to absorb as much heat as possible. The peacock butterfly and speckled wood actually press their wings on to the ground, probably gaining warmth from rocks or soil as well as from the sun.

Man's waste items can, because of their very hot microclimates, attract great numbers of insects. An old rubber tyre can be a staggering 45°-50°C (113°-122°F), even on a chilly April morning. Many ground beetles and bugs take advantage of such hot-spots until they have reached their preferred body temperature of 25°C (77°F) or so; then they run off to catch food or search for a mate.

Clustering and sheltering Some insects multiply the effect of hot surfaces by basking in groups–the cluster conserves heat better than an individual basking on its own. This sort of behaviour is common among some groups of bugs, such as the nymphs of *Picromerus bidens*, and it is a well-known feature of ladybirds in spring. Eggar moth caterpillars spin special webs for basking in sunshine, and have been recorded reaching temperatures of 30°C (86°F) or so. At these temperatures they can digest food much more rapidly than in the cold, and therefore they grow very quickly.

While it is generally true that they are at the mercy of every vagary of their microclimate, some insects do attempt to control their own conditions. Insects such as leaf borers live in a tiny world of their own where humidity is high and large temperature fluctuations are absent. Web building, while enabling some insects to bask more effectively enables others to conserve humidity. Measurements taken inside the silken webs of peacock butterflies have shown that humidity is high inside these webs, keeping the caterpillars safe from summer drought.

Eggs in the microjungle Some microclimatic effects will never change, particularly those to which insects have adapted over thousands of years. One such case is the tendency of many insect species to lay their eggs in the tiny niches within their habitat which favour rapid growth and maximum survival. Some butterflies choose very warm places to lay; the female meadow brown is often seen investigating warm hollows low among the cut grass stalks in freshly baled hay fields, or in the ground vegetation on country tracks.

Insect occupants

Insects in the microjungle divide the various zones between them: **1** bare ground: tiger beetles, mining bees; **2** short turf: ants, grasshoppers; **3** soil: moth pupae, beetle larvae; **4** stem bases: plant-eating bugs, craneflies; **5** low vegetation: leaf-hoppers, figwort weevils; **6** tall vegetation: ladybirds, scorpion flies; **7** flower heads: hoverflies, common wasps.

Layers of the jungle

Above: Barmston Pond with mute swans on the water and flocks of wigeon and black-headed gull in the air.

BARMSTON AND SHIBDON PONDS

The county of Tyne and Wear in north-east England is named after two rivers that dominate the area, yet away from these the county has few aquatic habitats. Two exceptions are Barmston Pond, a site for many rare passage migrants, and Shibdon Pond, which has been set aside as a nature reserve.

Below: Shibdon Pond in winter. The site was first created a nature reserve by Blaydon Urban District Council, who bought it in 1968 for this purpose. Since 1979 it has been under lease to the Durham County Conservation Trust, who are now responsible for its maintenance.

Shibdon Pond and its surrounding area lie on the south bank of the River Tyne in the middle of the houses and factories of Blaydon. It consists of 4ha (10 acres) of open water and 10ha (24 acres) of wet and dry grassland, marsh and scrub. Barmston Pond lies across the county from Shibdon, being sandwiched between the new town of Washington and the old shipbuilding town of Sunderland. It lies further away from the River Wear than does Shibdon from the Tyne, but it is still near enough to attract birds using the river as a migration route. Barmston is smaller than Shibdon, with an area of about 2.4ha (6 acres) of flooded grassland. The surrounding fields are used mainly for cereal crops, but some dairy farming is also carried out.

The two ponds have several features in

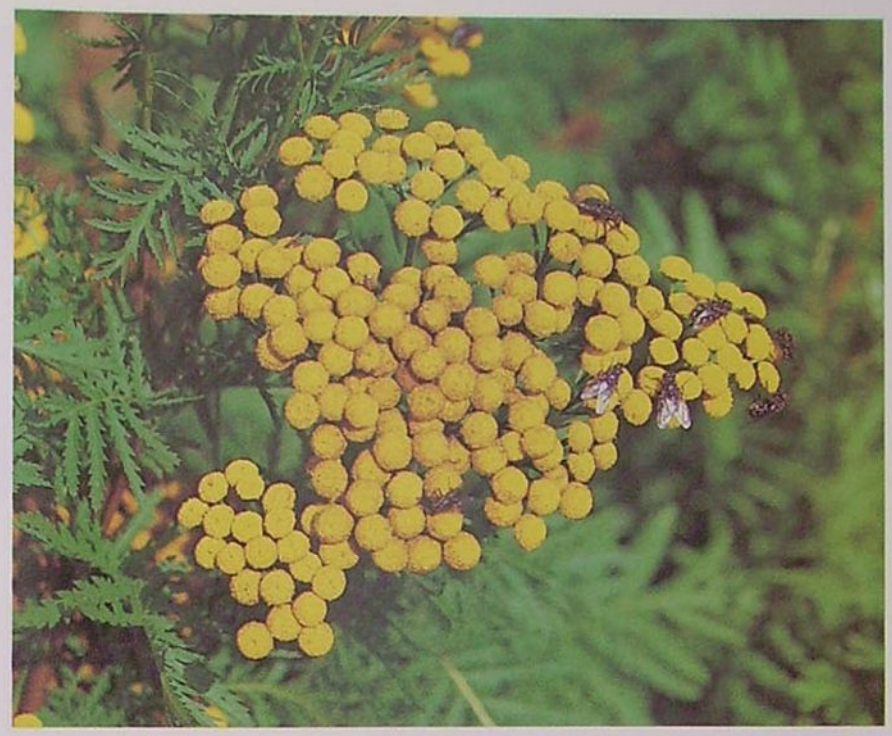
common. Barmston Pond has arisen solely because coal mining in the area has caused the land to subside. Shibdon Pond, though it lies on the old flood plain of the Tyne and is thus a traditional wetland site, has also been greatly affected by mining subsidence. Until recently both ponds had a companion pond associated with them. Unfortunately, both are now lost. The one at Shibdon was used as a tip for domestic council refuse, while Barmston's shallow muddy-edged pond–which was much favoured by birds–was lost when the local farmer drained the corner of the field.

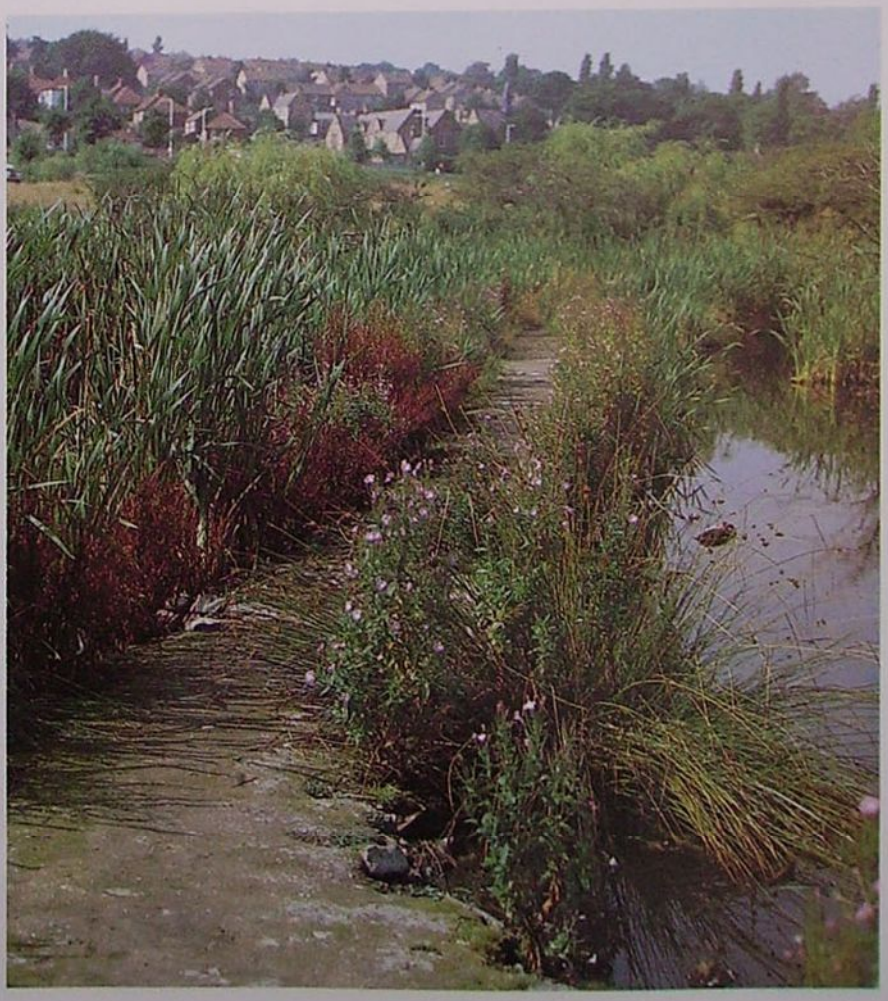
Both of the large ponds are, however, still vitally important as wetlands in a county short of such habitats. Barmston has an important role to play as a 'staging post' for migrating birds in the spring and autumn, and also as a relatively undisturbed area where wildfowl and other wetland birds can pass the winter in safety. Shibdon, with its much more diversified habitats, fulfils the above two roles and also provides living space throughout the year for a whole range of plants and animals not found at Barmston.

Barmston Pond The vegetation of Barmston consists mainly of low-growing aquatic plants, with common spike-rush, common water-plantain and floating pondweed dominating the water margin in the spring and summer. In winter the pond increases in size as it collects more and more surface water. As it does so the water margin spreads out and comes to consist of flooded grassland and cow-puddled mud, a combination that, along with a plentiful supply of seeds and invertebrate animals, has brought many rare birds to Barmston. Of the 136 species of bird that have been recorded so far there, 35 of these have been waders and 22 have been wildfowl. Notable among the rarer birds have been lesser yellowlegs and Wilson's phalarope from North America, broad-billed sandpiper and Temminck's stint from Scandinavia and collared pratincole and spoonbill from southern Europe. Other rarities include black kite, purple gallinule (the first British record of this bird), grey phalarope and red-footed falcon.

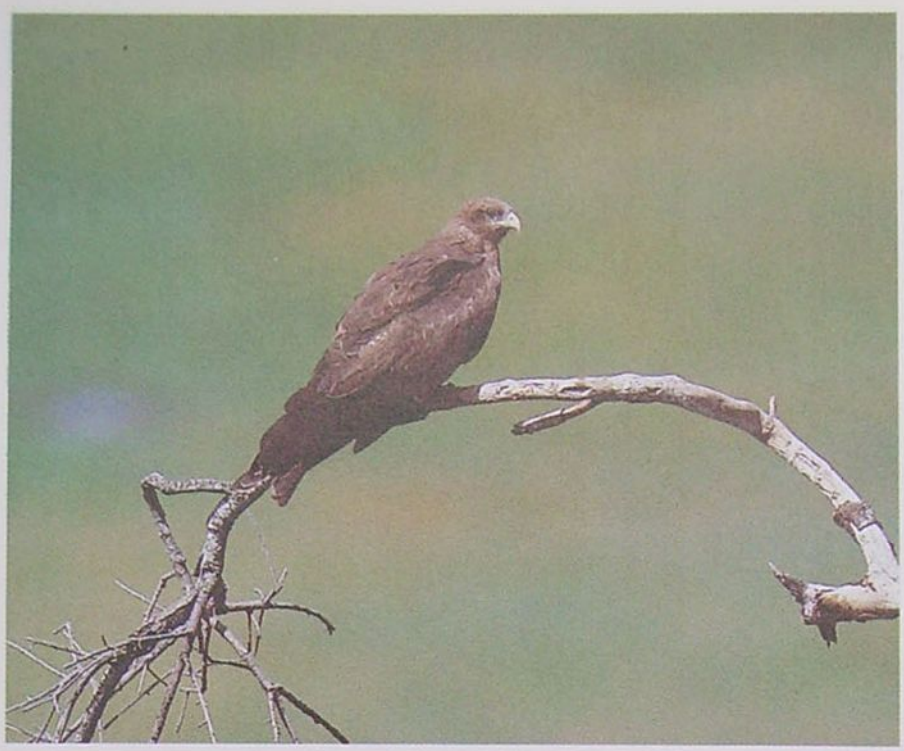
Most of the very rare birds were seen in the period when both ponds at Barmston were intact. Since the draining of the smaller, shallower pond the number of waders has dropped considerably. What is doubly distressing is that the small area of land the draining released for farming has shown itself to be very unproductive–though the water has gone from the surface the land is apparently still waterlogged and in most years the crops fail.

The larger, remaining pond still attracts good numbers of birds. Up to 120 wigeon (with an exceptional 250 in 1983) arrive in October and winter on the pond, and shovelers and mallards are usually present in late summer. Large numbers of migrating birds sometimes break their journey at Barmston, for example ringed plovers in spring and groups of ruff (more than 200), curlew sandpiper and little stint in late summer. As with most stretches of inland water Barmston carries a large population of non-breeding black-headed gulls, with smaller numbers of herring gulls and lesser black-backed gulls. On the short cattle-grazed turf around the





Above: Tansy is a common plant of the dry grassland at Shibdon, while (below) the reed-beds there act as assembly points in late summer for thousands of birds such as swallows about to migrate south.



Above: One of the most exciting of the rare birds seen at Barmston is the black kite, a vagrant from the Continent.

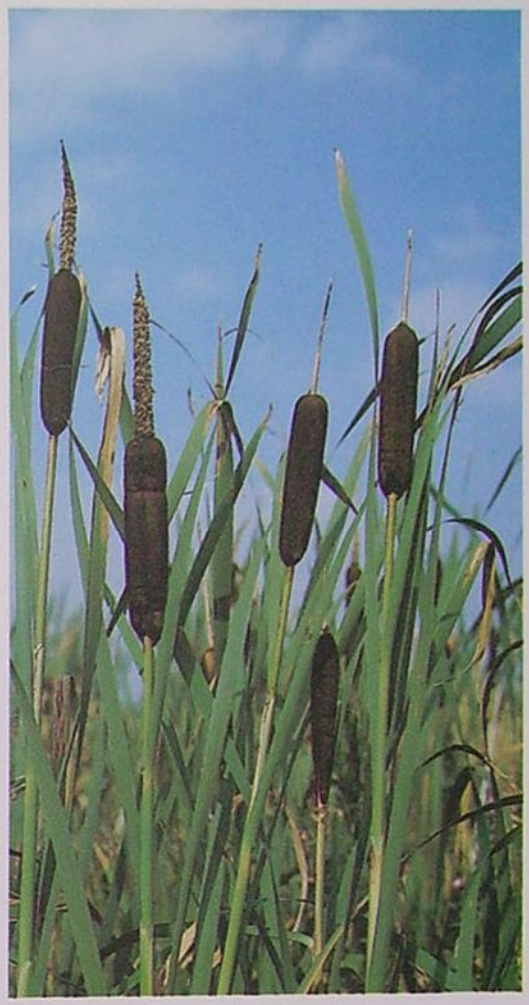
Below: A water vole feeding in a reed-bed.

pond lapwings and starlings can always be seen feeding.

Shibdon habitats Whereas Barmston consists simply of a pond surrounded by fields Shibdon has a much greater diversity of habitats. The centrepiece is, of course, the pond itself, which attracts large numbers of wintering wildfowl such as pochard (more than 300), tufted duck, wigeon, teal and shoveler. The fishes in the pond attract regular visits from kingfishers, herons, cormorants and goosanders, all of which find the clear water of the pond easy to fish in.

Some of the water of Shibdon Pond comes from a number of natural springs arising at the base of a nearby scarp slope, but the main influx of water comes from an old mine shaft. The water from the shaft is heavily laden with iron which is deposited on the bottom of the pond as an orange-brown layer. No one yet knows what effect this iron is having on the pond's flora and fauna. One of the main problems facing the team of people who look after the site is that the rate of water flowing into the pond is increasing, gradually raising the level of the pond and allowing greater reedmace to spread. There is to be an attempt to control the rising level of the water by installing a weir where the stream flows out of the pond to the Tyne.

Marsh and grassland The marshy area surrounding the pond is dominated by greater reedmace and reed sweet-grass, both plants providing food and breeding sites for coots, moorhens, mallards, and water voles. Various insects, such as water boatmen, diving beetles, dragonflies, damselflies and mayflies, can also be seen in the vicinity. A small area of common reed is being encouraged to spread by the reserve management, who hope it will replace some of the greater reedmace since



common reed supports a more varied animal population.

Over a small section of marsh the reedmace has been deliberately removed to make a 'wader scape'–an area of very shallow water and exposed mud. This, it is hoped, will attract and provide food for waders such as greenshanks, redshanks and wood and green sandpipers. At present these birds explore the reserve but do not stay long because of a shortage of suitable feeding sites.

Shibdon Pond also has interesting areas of wet and dry grassland, particularly the wet grassland, of which there is very little in the rest of the Tyne valley. Two species of orchid are abundant: the common spotted and the northern marsh, the pale spotted flowering heads of the former contrasting with the dark purple heads of the latter. Yellow rattle, lady's smock and great burnet also grow here. Where the wet grassland has been disturbed recently, and pockets of slightly drier soil form, small clumps of heather have become established. Some areas of wet grassland are being threatened by encroaching sallow.

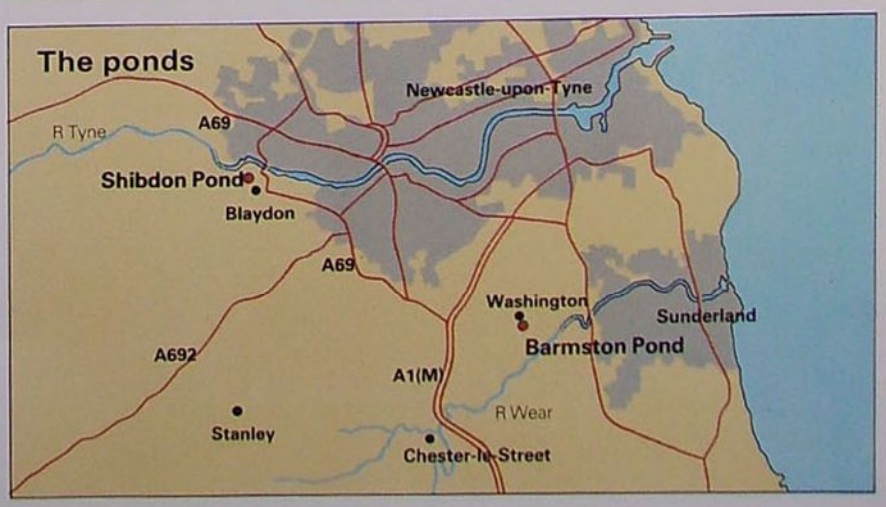
A recent addition to the habitats of Shibdon is dry grassland, which has formed on the site of a colliery that was demolished in 1951. Typical plants of this habitat include common toadflax and tansy. Butterflies such as large skipper, common blue and orange tip are fairly common during the summer. Among birds, goldfinches, linnets, dunnocks, sedge warblers and reed buntings are all common.

Human pressures While Barmston Pond is visited only by dedicated birdwatchers seeking an elusive rarity the Shibdon Pond reserve attracts a large number of visitors, which puts great pressures on the wildlife of the area. To control these pressures and safeguard the areas that are of particular interest to naturalists, the management have constructed a timber broadwalk footpath and a nature trail through the various habitats. Thanks to this work the future of the reserve looks comparatively secure. Barmston Pond, on the other hand, is still threatened by attempts to drain it and, until it receives legal protection, its long-term future must be in doubt.

Above: One of several attractive butterflies at Shibdon is the orange tip, which lays its eggs on lady's smock.

Right: Much of the marshy area at Shibdon is dominated by reedmace, though the reserve management are trying to control its spread and replace it with reeds.

Below: Wigeon winter at both Barmston and Shibdon Ponds. In spring they fly to their breeding grounds to the north.



FIELDS OF THE LOWLANDS

Lowland Britain has been under intensive cultivation for three thousand years. The land has been cleared, divided, discarded, reclaimed and reshaped time after time, creating an elaborate network of fields.

Opposite left: The patchwork landscape of Britain and Ireland which we take for granted, like this view of hedgerows and forestry plantations in County Cork, has evolved from banks, hedges and walls enclosing fields of every conceivable shape and size. They date from every era of agricultural history. Huge, unedged arable fields such as the view near East Ilsley, Berkshire (below), are a very modern phenomenon.

A field is enclosed land cleared of its natural vegetation, where crops are grown for harvest or grazing by domestic animals. Clearance usually means reducing the site to bare earth by cultivation, so that crop plants can be grown at high density with a minimum of wild competition. If the farmer simply wants to graze his stock, however, only the large trees need to be removed; confined on the land by an enclosing fence, hedge or wall the animals will eat everything down to ground level until only low-growing grasses and herbs remain. In theory, therefore, the field may be either arable and repeatedly cultivated, or pastoral with a ring fence surrounding closely-cropped grassland.

In practice this distinction has been eroded by two of the basic requirements of agriculture: the maintenance of fertility and the protection of the crop. For millenia the chief source of fertiliser for arable fields has been from livestock on the field itself. This requires a fence. Conversely, when the crop is high and tempting, the animals must be kept out. Consequently arable fields have, in general, been provided with stockproof boundaries.

Boundaries The boundary is the most interesting part of the field, both ecologically and historically. The field itself changes constantly, but a boundary marked by a substantial hedgebank or wall is relatively permanent. Even when it is removed it may often be traced so that the whole process of landscape domestication, from wilderness to rural food factory, can be reconstructed.

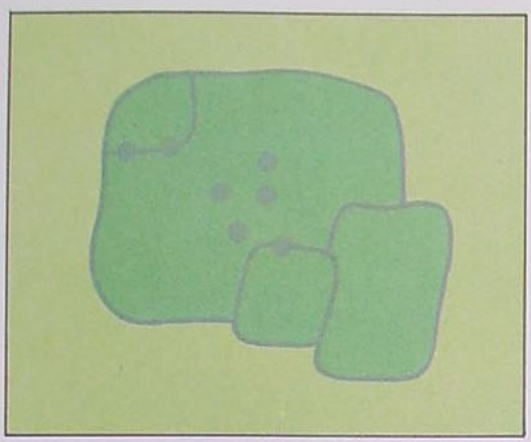
There are two basic types of enclosure–the first produced by the primary phase of clearance and the second by the subdivision of the cleared land. Each has its characteristic boundary pattern, resulting from the relative scale of each operation. Generally, it is much easier to fence open land than to clear forest or reclaim heath. Large areas can be dealt with in a short time, and the tendency is to draw sweeping lines across the landscape and then subdivide the areas into neat parcels.

By contrast, clearance is, or was, slow work. With limited resources and other calls on his time, an individual farmer will only clear a small area each season: perhaps one or two fields. The work proceeds according to inclination and expediency, resulting in an irregular plot which bears little relation to previous clearances. The oldest fields to be identified in Britain provide excellent examples of this process.

Most of the earliest fields were, and still are, irregular in form, with boundaries defined by the limits of clearance rather than agricultural logic. They owe their survival partly to inertia and partly to pastoral farming, for which stockproof boundaries are more important than field size and shape. For mechanised arable farming, of course, these priorities are reversed, with notorious consequences in the modern era. Farm machinery is no novelty,

Changing fields

The oldest fields in Britain date from around 3000BC and are preserved by their remote situation on Dartmoor. They are roughly circular plots bounded by the remains of stone walls (**1**). The sequence of clearance is apparent from the way each plot has been added to the existing pattern. The earliest field, which presumably had to be prepared in a hurry to get the crop in on time, is also the smallest. Similar field networks (**2**) from 500BC or earlier are still in use in west Cornwall on the Penwith Peninsula. The classic examples of piecemeal enclosure (**3**) are found in pastoral areas that were once heavily wooded, such as the heartland of Devon where in many cases today's hedges are the original boundaries of cultivation. When the plough was introduced many fields were cleared to roughly square proportions (**4**). Many of these systems were superseded by the open field system based on furlongs divided into strips (**5**). Several furlongs were enclosed to form a huge, subdivided field.



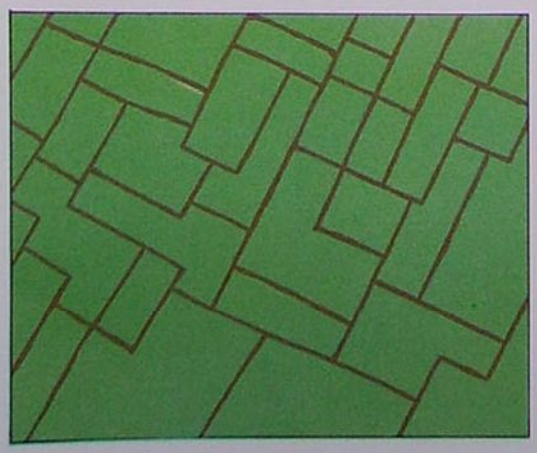
1 The earliest walled fields on Dartmoor.

2 Slightly more complex walled field networks.

Remains of ancient walled fields at Longstone Moor in Derbyshire.

3 Small, irregular fields, with high hedges.

The hedges here could be the original boundaries of cultivation.

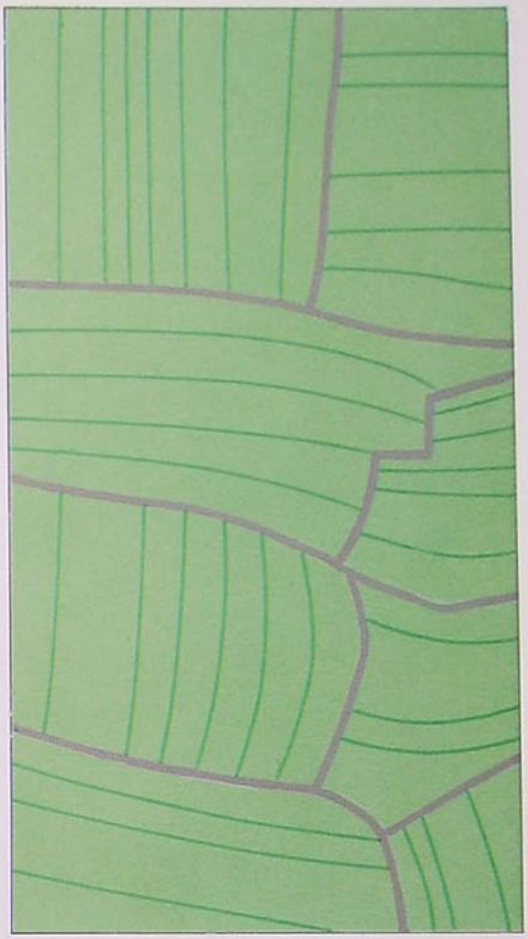


4 Rectilinear fields made ploughing easier.

Rectilinear fields in Malham, Yorkshire Dales.

Medieval terraced strip fields extended cultivation to marginal land.

Parliamentary enclosure hedges; (below) modern electric fencing.



5 Open fields: furlongs divided into strips.

however. The first machine-based agricultural revolution took place in the late Stone Age with the invention of the plough.

An agricultural revolution The early plough was a lightweight, manoeuvrable implement, but it nevertheless required two oxen to pull it, and oxen, like any other power unit, are most easily driven in a straight line. This practical consideration led to the development of the so-called 'celtic' rectilinear field, traces of which are still seen in chalk downland areas subsequently grassed for pasture. Evidence from Yorkshire suggests that these fields superseded a pre-existing system of irregular clearances. If so, the grid pattern so strikingly preserved at sites such as Bulford Down in Wiltshire is the result of a large-scale re-organisation of field boundaries in a cleared landscape, probably initiated in the Bronze Age (*c*1000BC) in response to improved technology–a familiar process.

The proportions of these fields tend to be roughly square. The primitive plough was little more than a pick hauled through the ground by its handle, and efficient cultivation required a criss-cross ploughing technique which is most easily achieved in a square enclosure. Advances in plough design gradually made this unnecessary, and by the time of the Roman invasion in AD43 long enclosed fields were in use alongside the old type, sometimes created from them by boundary removal.

This pattern persisted throughout the Romano-British period and beyond, but has only survived to the present in fossilised form in hilly, marginal country which later arable farmers did not consider worth cultivating. In the rich lowlands it suffered the same fate as the irregular clearances which probably

Below: This land was probably first cleared to erect the prehistoric ringwork. The farmstead, perhaps dating from medieval times, is surrounded by small fields which may have been the first to be enclosed.

Left: The wheat harvest near Glyndebourne in Sussex. On big arable farms like this the enclosed field is now a redundant concept. Since artificial fertilisers replaced animal manure on the cornland, stockproof boundaries have become superfluous, and merely hinder the progress of machinery. In these areas the enclosures that date from Georgian times are fast going the same way as the medieval strips which preceded them. Elsewhere they still do a good job restraining and sheltering sheep and cattle, as do many Tudor, medieval, Anglo-Saxon and prehistoric fields which still survive, largely unrecognised, to give each rural landscape its distinctive character.

Below: Weardale in County Durham–a traditional landscape of small uneven fields, many probably just the same size as they were centuries ago.

preceded it, being reorganised to accommodate new methods of cultivation. The most spectacular of these was the open field system, which came to dominate the heart of England in the early Middle Ages.

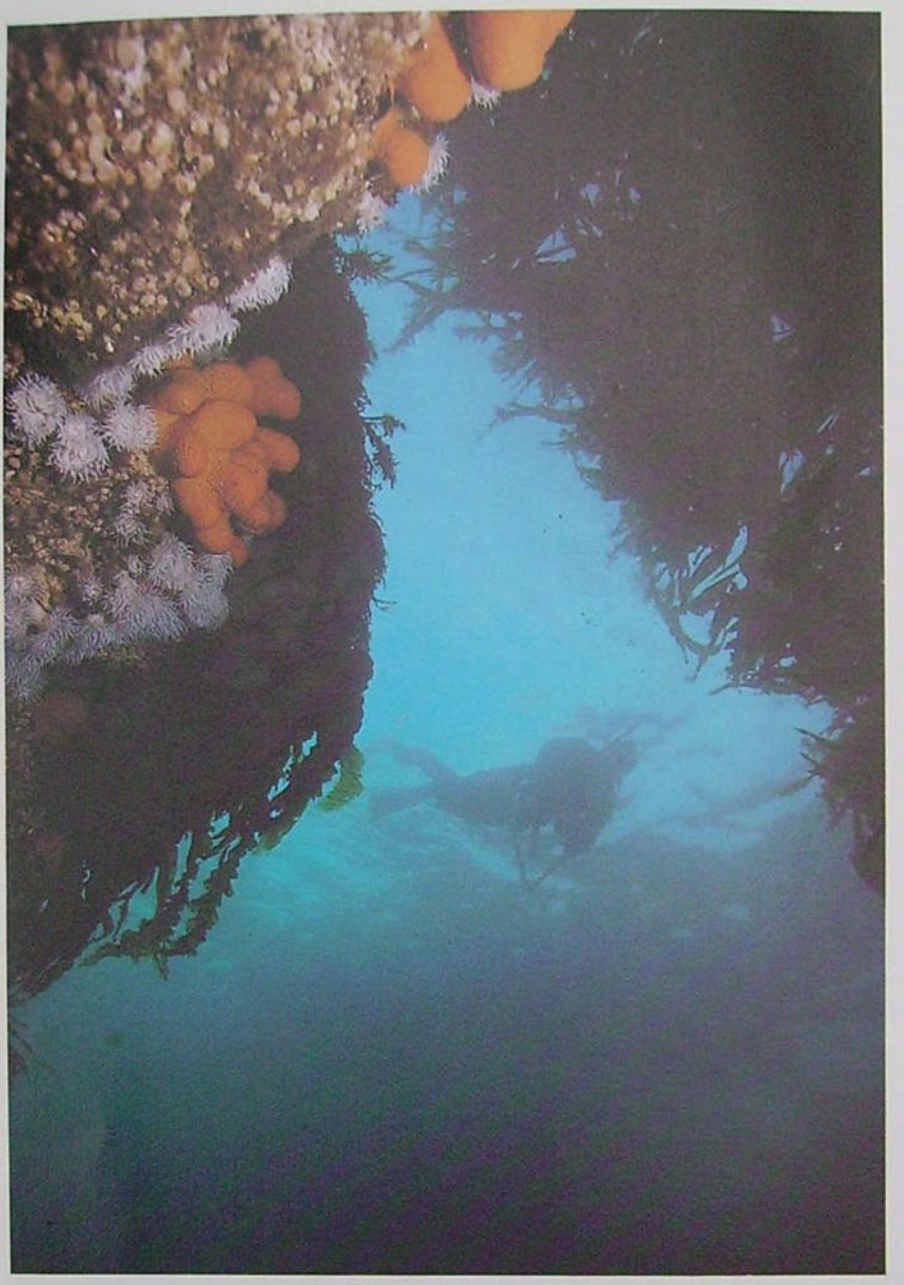
Open fields The basic unit of open field agriculture was the strip, an elongated plot of land only a few furrows wide. This was devised to suit a heavy plough pulled by a long ox-team, reasonably efficient in a straight line but difficult to turn. The fewer and longer the furrows, the fewer turns per acre of land. The strips were bundled together in furlongs, a number of which were enclosed by a ring fence to form an enormous subdivided field. Two, three or more such fields comprised the arable land of the village, and every villager held one or more strips in each furlong. The whole arrangement resembled a vast complex of allotments.

Open fields are so named because originally the individual strips were not fenced. They were cropped more or less in unison so that the whole field could be turned over to cattle and sheep when necessary. Nevertheless, the internal divisions were defined on the ground by a surface drainage system known as ridge and furrow, formed by turning soil towards the centre of each strip, leaving a shallow gully at the edge.

As with previous arable systems, the open fields were superseded by others more appropriate to changed social and technical conditions. By the late Middle Ages the decline of feudalism had encouraged the rise of the independent yeoman farmer, and a return to small, enclosed fields which could be worked independently of their neighbours. Such fields were, and are, the norm in regions such as Devon where the strip system had never been established, but they are the result of primary clearance. In areas of former open fields many of the new enclosures created in the 15th to the 18th centuries were based on the old strip and furlong boundaries; most are still in use today.

In contrast to this re-use of the old divisions, many of the open fields still unenclosed by the mid 18th century were reallocated by Act of Parliament, and divided by straight lines drawn without reference to previous boundaries: a classic example of large-scale subdivision of open land. Such 'Parliamentary enclosure' is characteristic of the English Midlands, a landscape of long, straight hawthorn hedges which are, at most, only 200 years old.

Even younger are the hedges put in to subdivide fields for paddock grazing, a system whereby animals are confined to a small area of grass to ensure they eat it all when it is at its most nutritious. The introduction of barbed wire in the 1870s made such additional hedges unnecessary, and most of them have been taken out again in favour of wire fencing systems which can be moved as required.



UNDERWATER AT ST JOHN'S POINT

At the tip of a promontory in Donegal Bay is St John's Point, where a submerged cliff is the home of a magnificent range of marine animals. Access is unrestricted–but divers should remember to avoid harming this unspoilt natural community.

St John's Point is a peninsula 8km (5 miles) long and roughly 1km (½ mile) wide which projects into Donegal Bay on the west coast of Ireland. The peninsula runs south-west, towards the prevailing winds which blow straight in from the Atlantic Ocean. Here the sea has eroded the hard carboniferous limestone rock into steep cliffs, caves and gullies, and some of these cliffs extend under water. The pasture on the headland and the sea cliffs support a typical limestone flora, with orchids, kidney vetch and thrift providing a colourful display of flowers in the spring: but the animals and plants that make this place really interesting live out of sight of most people, beneath the water.

Above: A diver at St John's Point, seen from under the overhang; the orange shapes are soft corals, and the white ones are anemones.

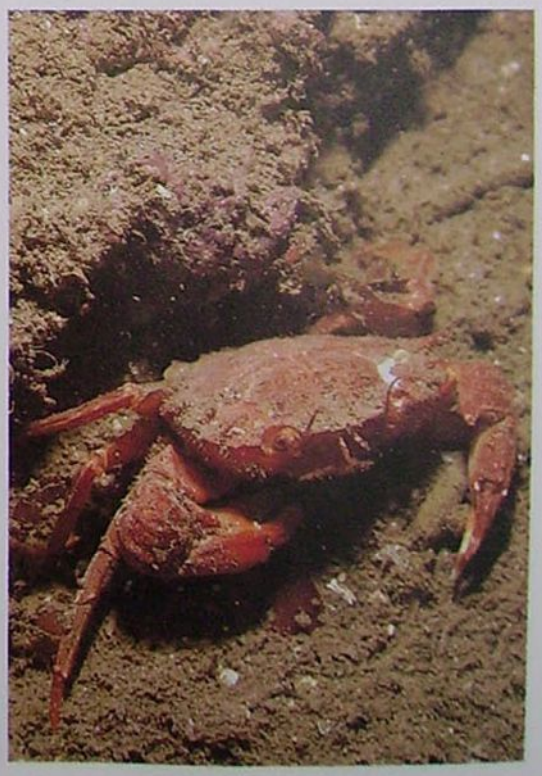
Right: *Bathynectes longipes,* a rare crab found at St John's Point.

Underwater cliff At the end of the peninsula, in a small bay, is a concrete jetty that serves the lighthouse on the headland. If we put on diving equipment here and swim out to a partly submerged rock some 100 metres out to sea, we can descend into a world dominated by seaweeds and fishes.

Just to the south of the rock there is a roughly vertical underwater cliff, which starts only a metre or so beneath the surface. The top of this cliff is fringed with kelp plants–large, tough, brown seaweeds that stretch out from their points of anchorage towards the light, reaching a height of 1.5-2m (5-6ft). Below the kelp, on the face of the cliff, there is little light, especially where the cliff is overhanging. A few red seaweeds grow on horizontal ledges where they can get enough light, but most of the rock is covered by animals–sea-anemones, soft corals, bryozoans and sponges.

Beneath the largest overhang is a huge patch of plumose anemones, looking like feather dusters on short stalks. Vertical surfaces in shallow water are covered with a carpet of tiny jewel anemones, each individual only 1cm (½in) across but clustered in patches up to 1m (3ft) in diameter. These anemones are colonial, each patch growing by division from one individual, and the patches are often of different colours, green, pink, brown and purple.

Looking lower Deeper down the cliff face,



the water movement from wave action is less severe, and some mobile animals can cling to the steep surface. Sea-urchins are conspicuous, moving slowly across the rock and chewing off the fixed animals and plants. They continuously create patches of bare rock for recolonization by other animals and plants. On horizontal surfaces and small ledges where sediment tends to collect, there are many black sea cucumbers, *Holothuria forskali*, resembling large sausages. They feed on the sediment, picking up particles with the sucker-like feet which surround their mouths, and moving slowly like giant caterpillars on hundreds of tiny tube-feet. Here the rock face is mostly covered with the solitary cup coral *Caryophyllia smithii*, whose hard skeleton probably protects it from the grazing sea-urchins.

Small patches of other anemones, such as the white and orange *Sagartia elegans*, soft corals and hydroids occur on the cliff face. Some species choose crevices while others prefer projections where water movement is more pronounced. St John's Point is one of the few places in the British Isles where all three species of soft corals, or dead men's fingers, occur together. While the common orange or white *Alcyonium digitatum* grows mostly on projections and ridges, the smaller pink *Parerythropodium coralloides* forms colonies the size of the tip of your finger in crevices and small caves. The large red and white colonies of *Alcyonium glomeratum* are found on boulders and rock faces out in deeper water at the base of the cliff.

Animals in the caves Towards the bottom of the cliff are two horizontal ledges on the limestone rock. Here the sea has eaten into soft layers of the rock known as bedding planes to produce caves which are like horizontal slits going back 3-4m (10-13ft) into

Above: This specimen of the sea slug *Cuthona rubescens* has been preserved as the holotype, or definitive example of the species. This means that subsequent specimens must match this one if they are to be labelled the same species.

Right: *Parazoanthus axinellae*, a colonial anemone found on the outlying rock face.

Below: The cuckoo wrasse is unafraid of divers and will allow close inspection.

Above: The iridescent seaweed *Drachiella spectabilis* grows in summer on the limestone rock at the foot of the submerged cliff. It occurs in deep, clear water along the Atlantic coasts of the British Isles.

Below: A ling among the boulders at the foot of the submerged cliff. In recent years St John's Point has become popular with divers, some of whom kill these and other beautiful fishes such as wrasse and pollack with spearguns for 'sport'.

the rock face. These are as much as a metre high at the entrance, but taper down to form narrow dark crevices at the back.

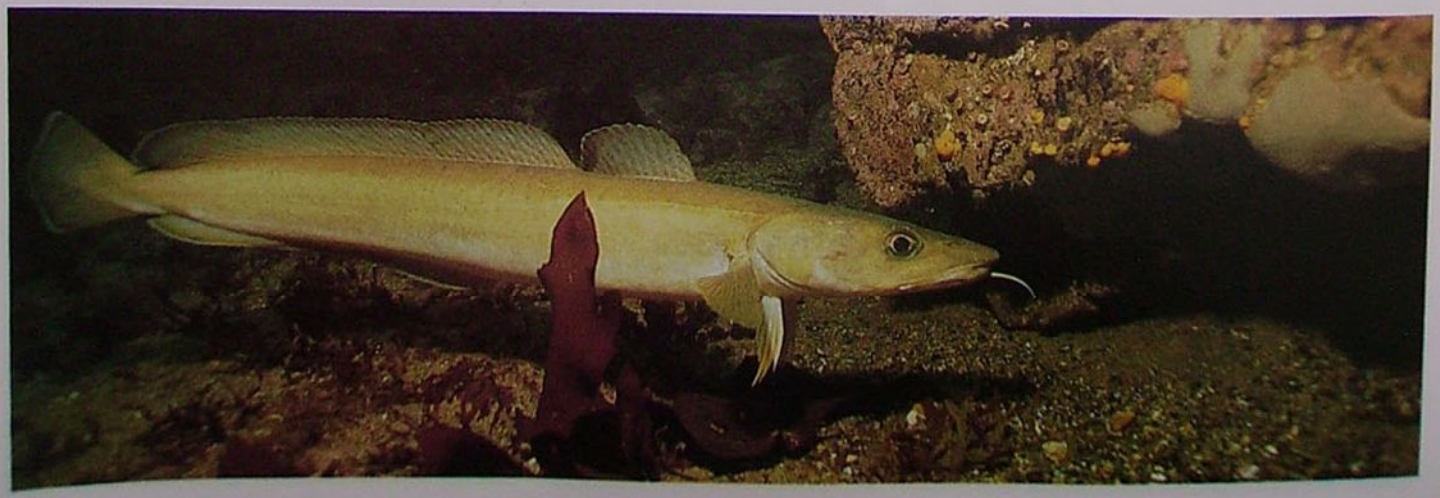
These caves act as shelter for fishes and crustaceans in the daytime and at night. Some of the inhabitants leave the caves as night falls, while others take up their places inside after spending the daytime in the open water. At night conger eels, squat lobsters and a rare crab, *Bathynectes longipes*, come out of the caves, while a torch directed into the back of the cave will reveal ballan wrasse and cuckoo wrasse sleeping. Very little is known about the crab *Bathynectes longipes*; it is recorded only from quite deep water in the south-west of Britain, where it was caught in nets, and St John's Point is the only place where divers have observed it. It is possible that the nocturnal behaviour of the crab, and its habit of living in rock crevices, has resulted in its rarely being captured by zoologists. A fish with similar habits also lives in these caves. This is the leopard-spotted goby, which is now known to be common all round the west coasts of the British Isles but was unknown here until the 1960s.

The caves also provide a home for some fixed animals. The floors are mostly bare and covered with a thin layer of sediment but the ceilings are covered with jewel anemones and large patches of two sponges. One is the elephant's ear sponge (*Pachymatisma johnstonia*) and the other is the much rarer white *Thymosia guernei*. *Thymosia* is a southern species, occurring in France, south-west Britain and Ireland; it reaches its presently known northerly limit at St John's Point.

Sea slugs The encrusting sponges, bryozoans and hydroids on the cliff provide food for a number of species of sea slugs. *Antiopella cristata*, a transparent animal with iridescent blue markings, is frequently seen feeding on tufts of the bryozoan *Bugula flabellata*. A less conspicuous species is *Jorunna tomentosa* but its egg coils are often obvious near its food, the sponge *Haliclona*. In 1978 a new species of sea slug, *Cuthona rubescens*, was described and a specimen from St John's Point was used in the description.

Boulders and gravel At the base of the cliff is a slope of large tumbled boulders that have fallen from the rock face. Here more light penetrates from above, and the boulders are covered with seaweeds, small kelp plants and red algae in particular. Some starfishes are found here: the bright red cushion star, *Porania pulvillus*, which is about 10cm (4in) across from tip to tip, and the more slender, stiff *Stichastrella rosea*, which is pale orange in colour.

Many fishes come and go among the boulders: large shy pollack, timid ballan wrasse and friendly, bright-coloured cuckoo wrasse. Another fish that hides beneath some of the larger boulders is ling (*Molva molva*), which grows to a metre or more in length.



Stretching out from the boulders is a flat area of limestone rock, covered in places with coarse gravel. The rock supports a dense growth of seaweeds in the summer. Most obvious are the red leaves of *Delesseria sanguinea*, the finely branched fronds of *Heterosiphonia plumosa* and the occasional bright iridescent blue patch of *Drachiella spectabilis*. *Drachiella* is another of the species for which St John's Point is interesting to naturalists. This seaweed was found growing in the British Isles only recently, but is now known to live in deep clear water at a number of sites along the Atlantic coasts as far north as Scotland.

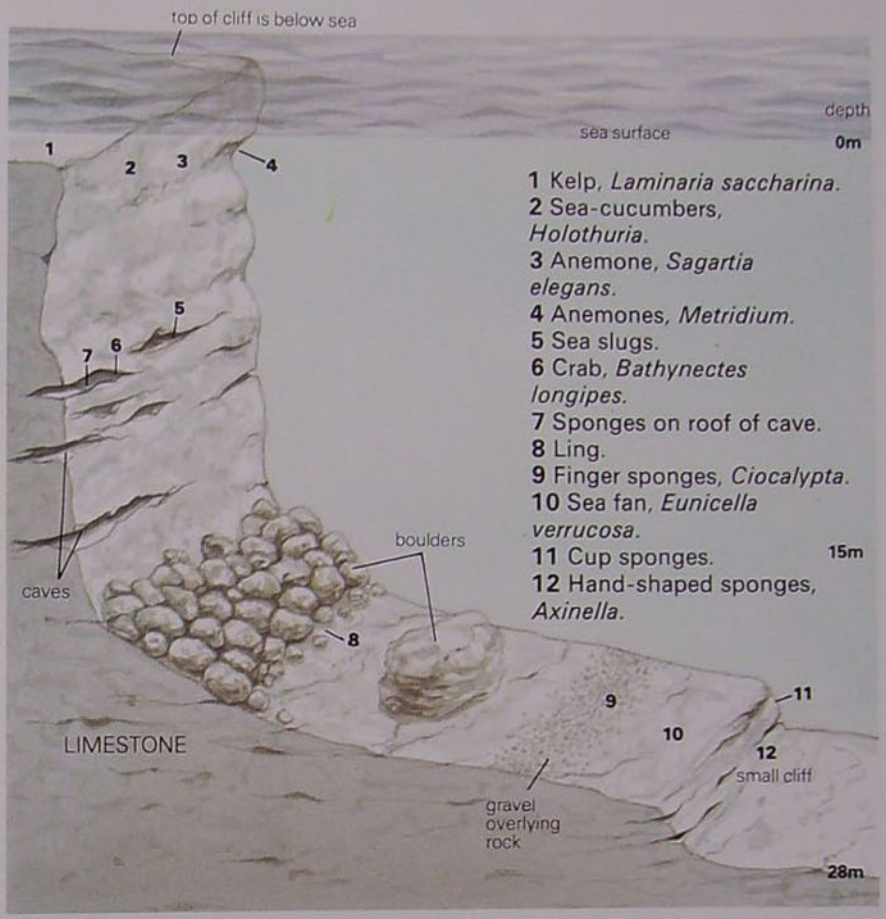
Where the gravel is deep enough it shelters some interesting burrowing animal species. The yellow heart urchin (*Echinocardium flavescens*) lives beneath a small dip in the gravel and reaches up to the surface with long tube-feet to collect edible material that settles into its hollow. The brittle star *Ophiopsila annulosa* extends its long legs up into the water, holding them like a net across the current, and trapping food particles. It is known only from one other site in Ireland.

Where only a thin layer of gravel covers the rock, there are some patches of the sponge *Ciocalypta penicillus*. This grows as a crust on the rock, sending up finger-like projections through the gravel to draw in water for feeding and respiration. This sponge is considered to be rare, but it might be more appropriate to say that it is the specialised habitat that is rare.

Outlying rock face About a hundred metres out from the base of the cliff is another small vertical rock face at a depth of about 28m (15 fathoms). There is not enough light at this depth for seaweeds, and the animals are quite different from those on the cliff. Several sponges are conspicuous: *Phakellia ventilabrum* and *Axinella infundibuliformis* both look like little conical goblets standing on the rock; *Axinella polypoides* is like a bright orange-yellow hand pointing upwards; and *A. damicornis* is more like a small wizened hand, mealy yellow in colour. Beneath overhangs are patches of the very thin sponge *Hymedesmia paupertas* in two colour forms, like bright blue and sea-green paint on the rock.

The colonial anemone *Parazoanthus axinellae* occurs under the same overhangs, and salmon pink sea fans, *Eunicella verrucosa*, stretch upwards from ridges and projections. These species are all characteristic of deep, clean oceanic water, and many of them are near their northern limits in County Donegal.

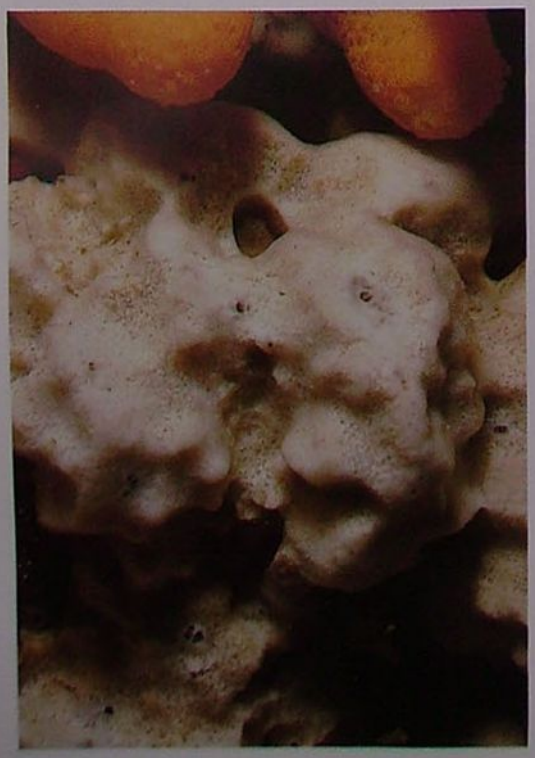
Looking beneath the surface



Above: The underwater cliff at St John's Point, showing the location of some of the animals that live there.

Left: This sponge, *Thymosia guernei*, lives only in small caves in limestone rocks. This strict habitat requirement may account for its apparent rarity.

Below: One of the burrowers in the deeper gravel patches is the brittle star *Ophiopsila annulosa*. Here a specimen extends four of its five limbs to catch detritus.



Above: The Dartford warbler is a member of the long-tailed group of *Sylvia* warblers. In spring its explosive song is heard on southern English heaths.

WARBLERS OF EUROPE

Every year, numerous vagrant warblers from the Continent are seen in Britain and Ireland. To account for them, we take a Europe-wide view of the group as a whole.

Warblers are among the birds most prone to vagrancy, a condition that fascinates birdwatchers because a vagrant is by definition a rarity–a bird that has gone astray on migration and made a landfall outside its normal wintering or breeding range. The reason for the particular proneness of the warblers is not known for certain, but it may be linked to their small size and the vast distances that some of them travel. Whatever the cause, the result for birdwatchers in Britain and Ireland is best judged by looking at the British Trust for Ornithology's *Species List*, which includes any bird reported, whether breeding, wintering or vagrant, in the two countries. In this list there are 42 species of warblers, of which only 14 are breeding birds: the remainder, or two-thirds of the total, are vagrants.

Vagrant warblers are, with a few Asian exceptions, European birds; therefore we have to take a Continent-wide view and, by describing the family as a whole, show the relationships between the various species–whether they may be migrants, visitors or vagrants in the British Isles.

The warblers of Europe are, as a general statement, small-sized migrants that journey each year from winter quarters in Africa northwards to spend the breeding season in northern Europe. This is, however, only partly true: of the 27 species breeding regularly in some part of the Continent or other, five are year-round residents in Europe, and three are resident (or partially so) in Britain–the blackcap, the chiffchaff and the Dartford warbler.

What do they eat? The fact that they can last the winter here implies that another common generalisation about warblers–that they are entirely dependent on insects for food–is not true, either of the wintering species, or of the migrants in the few weeks prior to migration. At this time, food demands are at their highest, for the birds are simultaneously raising their families, preparing to migrate by laying on fat for fuel, and perhaps also in the process of replacing feathers (moult). To supply the nutritional requirements for breeding, fattening and moulting, many if not all warblers rely largely on sugar-rich berries as the most efficient and most easily converted food.

A warbler's year An 'average' warbler's year consists of a series of regular stages: (1) winter in Africa, often south of the Sahara; (2) migration northwards in spring, arriving in Europe in April and May as insect life begins to become abundant; (3) raising one, two or three broods of young, depending on how late

Below: The melodious warbler is one of Europe's two *Hippolais* species, the other being the Icterine.

the arrival date is and how far north the breeding area; (4) moulting, though not all species do so at this stage: some moult completely, others not at all, and one or two moult only some of their feathers before departing, completing their plumage change when they reach their winter quarters; (5) fattening; and (6) the southward migration.

Not all migrate quite so far south as the Sahara–many warblers, including most chiffchaffs for example, winter in the Mediterranean basin, and many blackcaps have recently shown a tendency to winter as far north as Scotland, often resorting to gardens and to bird tables.

The main genera First, there are a few isolated cases: Cetti's warbler is the only representative of the genus *Cettia*, and the fan-tailed warbler is Europe's sole representative of a large Afro-Asian genus, *Cisticola*. These apart, most European warblers fall into five genera. Members of the genus *Phylloscopus* are normally called leaf warblers: they are usually small, their plumage is often drab green, yellow or buff, and they are often found in woodland.

The genus *Sylvia* contains many of the scrub-loving warblers like the whitethroat, and a long-tailed group (largely confined to the Mediterranean) like the Dartford and sub-alpine warblers. There are usually rather secretive, but have explosive calls and, often enough, a song flight that carries the male briefly high above the bushes before he dives back to cover. *Sylvia* warblers that do not belong to the long-tailed group include some–like the blackcap–that favour woodland. For some reason, most *Sylvia* warblers are much more colourful than their relatives: the Sardinian, sub-alpine and Rüppell's warblers are strikingly so.

The two common European members of the genus *Hippolais* are the Icterine and melodious warblers. These are birds of woods, parks and gardens; they partition Europe neatly, the melodious breeding in the south-west, including much of France and Italy, the Icterine taking over to the north and east of these two countries. Sadly, the British Isles do not belong to either of these ranges, and

Above: Rüppell's warbler is a scrubland bird of the genus *Sylvia* from the Mediterranean. Its range is a rather restricted one but the bird has occurred as a vagrant in Britain.

Right: Savi's warbler was extinct in Britain for a century, recolonizing the south-east in the 1950s. It is a reed-bed dweller of the genus *Locustella*. Our only other bird of this genus is the grasshopper warbler, which is widely distributed over Britain and Ireland.

Checklist of warblers

	DISTRIBUTION				HABITAT			BRITISH STATUS			
	S. Europe	N. Europe	W. Europe	E. Europe	wetland	woodland	scrub	breeding	vagrant	migrant	resident
Cetti's warbler	●				●			●	●	●	
Fan-tailed warbler	●				●		●		●		
Grasshopper warbler			●	●	●		●	●		●	
Savi's warbler	●		●	●	●			●		●	
Sedge warbler	●	●	●	●	●			●		●	
Blyth's reed warbler		●			●				●		
Marsh warbler			●	●	●			●		●	
Reed warbler	●		●	●	●			●		●	
Great reed warbler	●		●	●	●				●		
Icterine warbler		●		●		●	●		●		
Melodious warbler	●		●		●		●		●		
Dartford warbler	●		●				●	●			●
Marmora's warbler	●						●				
Sub-alpine warbler	●						●		●		
Sardinian warbler	●						●		●		
Rüppell's warbler	●						●		●		
Orphean warbler	●					●	●		●		
Barred warbler				●			●		●		
Lesser whitethroat		●	●	●		●	●	●		●	
Whitethroat	●	●	●	●			●	●		●	
Garden warbler		●	●	●		●	●	●		●	
Blackcap	●	●	●	●		●		●		●	●
Greenish warbler				●		●			●		
Bonelli's warbler	●		●			●			●	●	
Wood warbler		●	●	●		●		●		●	
Chiffchaff	●	●	●	●		●	●	●		●	●
Willow warbler		●	●	●		●	●	●		●	

Hippolais warblers are normally only scarce vagrants.

Two genera remain: *Locustella* (so named because several have songs that sound like grasshoppers or locusts), a genus of brown, streaky marsh-loving warblers; and *Acrocephalus*, most of which are plainish brown, reed-bed dwellers.

Warbler habitats Warblers exploit the European countryside extensively, from the thorny and very dry scrub of the Mediterranean coastline as far north as the northern limit of trees and scrub in the Arctic tundra. This includes a considerable range of habitat types, and a round-up of the European warbler species is probably most effectively carried out on the basis of habitats.

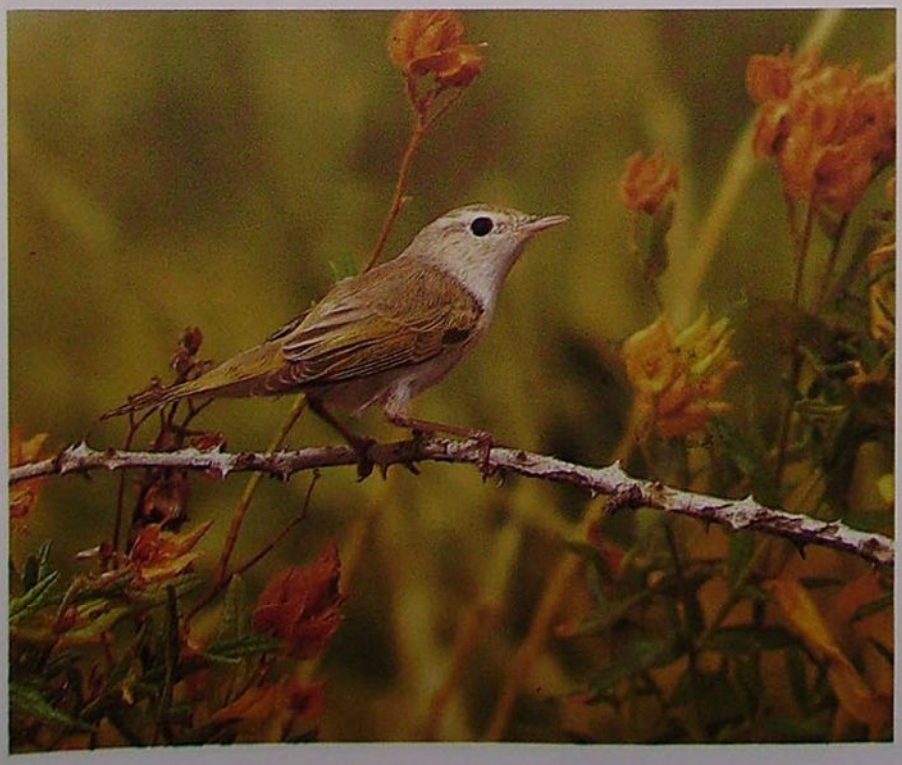
Wetland warblers These are widely distributed across Europe, though only the sedge warbler and Blyth's reed warbler are able to penetrate much to the north of the Baltic Sea. Some, like Savi's and the great reed warblers, which are most numerous in the south, seem to demand extensive reed-beds, while marsh warblers can occupy a small clump of damp scrubland. The reed warbler (and great reed warbler) build suspended nests which they always attach to reed stems, and these birds are therefore found where common reed occurs. It is more typical for warblers to nest in the dank marshland growth, usually low down and amazingly well concealed.

Woodland warblers These include birds from three different genera: *Phylloscopus*, *Sylvia* and *Hippolais*. They often feed high in the canopy, and the commonest *Phylloscopus* birds–the chiffchaff, willow warbler and wood warbler, together with Bonelli's warbler from further south in Europe–all hover to catch small flying insects, or to pick them from leaves, as well as searching the twigs on foot.

Above: A whitethroat puffs out its chest in song, displaying the white patch of plumage that gives the species its name. It is a scrubland warbler of the genus *Sylvia*, but not of the long-tailed group to which the Dartford warbler belongs.

Right: The marsh warbler fixes its nest to stems of broad-leaved thicket plants such as this willowherb. This is a similar style of construction to that of the reed warbler, except that the latter always fixes its nest to reed stems. Both birds are in the genus *Acrocephalus*.

Below: Bonelli's warbler, a woodland dweller from southern Europe.



The genus *Phylloscopus* is probably central Asian in origin–certainly this region is its stronghold, with some two dozen species. As they are mostly rather uniform and greenish, identification becomes an increasingly difficult problem as the European birdwatcher travels further east!

Scrubland warblers In the northern parts of Europe, the commonest warblers of scrubland are the whitethroat and lesser whitethroat, both *Sylvia*. In some of the few remaining heaths, the whitethroat is joined (even as far north as southern Britain) by the year-round resident Dartford warbler. The two whitethroats have, however, found alternatives to heathland or other scrub habitats by adapting to waste land and farmland hedgerows.

Scrubland warblers nearly all have fragmented, scratchy songs, but in contrast the barred warbler, breeding in the north and east, is often ranked as equal to the garden warbler in richness and purity of tone. But the greatest interest in the scrubland warblers must lie in their variety in the Mediterranean basin.

DONEGAL: A PLACE OF PARADOXES

To the botanist, Donegal is a puzzle: its mountains are bleak and windswept yet support more species of alpine flowers than anywhere else in Ireland, while its valleys and lough shores contain plants more often seen in Spain, Portugal and even America.

County Donegal occupies the extreme north-western corner of Ireland. It is a mountainous place, a land of misty rain and wind, covered with a blanket of peat. The mountains, composed of ancient metamorphic rocks (schist, gneiss and granite), tend to form great parallel ridges with long valleys in between, striking south-westwards from the Inishowen Peninsula to Donegal Bay.

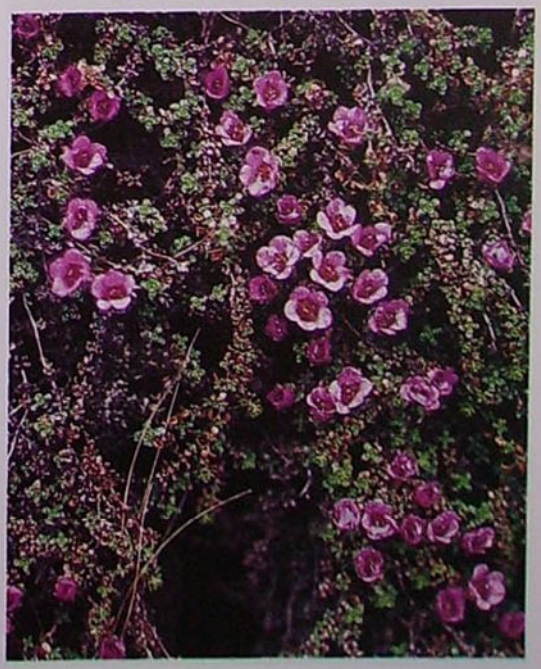
The first impression one gets of Donegal is of a barren and bleak landscape devoid of trees. Yet the high mountains support an interesting alpine flora, and in spite of the bleak landscape, the lowland plants include species of southern origin, the famous 'Lusitanian' plants from Spain and Portugal.

Above: The coastline of Donegal is rugged and deeply indented with long sheltered bays; there are many fine sandy beaches as well as ocean shattered cliffs.

Right: Alpine plants such as purple saxifrage are normally found on the northern side of mountains in Ireland, sheltered from the heat of the sun. In Donegal this plant species grows on the northern slopes of Slieve League.

This mixture of plants demonstrates that the climate is not as severe as it seems. Given shelter, the southern plants will flourish, often alongside alpine species.

Slieve League On the coast of Donegal Bay, in the far south-west of the county, is one of Ireland's most spectacular mountains–Slieve League, 601m (1970ft) high. On its northern flank is the remote valley of Glencolumbkille, renowned for its ancient monastic ruins. The



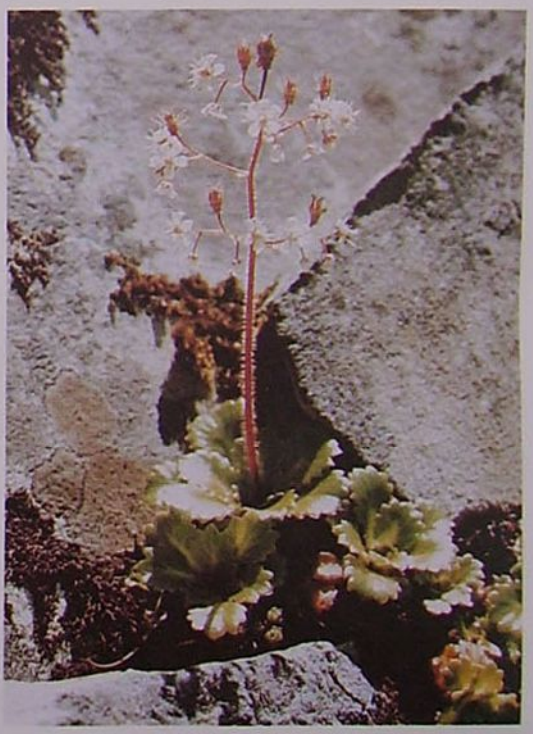
mountain's southern side has disappeared into the ocean, leaving a nearly vertical cliff from ocean to summit, the highest cliff in the British Isles.

It is well known that the best places to search for alpine plants in Ireland are the northern sides of mountains, where the sun is never too harsh and the environment is always cool and moist. Slieve League is no exception. On the smaller cliffs of the northern side, dwarf willow grows with bearberry, mountain avens, alpine meadow-rue, alpine clubmoss, purple saxifrage and many other alpine species. In fact there are more alpine plants on Slieve League than anywhere else in Ireland.

The mountain of Muckish The highest peak in Donegal is Errigal, 752m (2466ft) high, a spectacular quartzite cone, the slopes of which are covered in treacherous screes. Its flora is less interesting than that of Slieve League, but the summit commands a superb panorama of other mountains. To the north-east is Muckish, a 'table-topped' quartzite monolith (a block of rock). It has a fascinating flora and can be climbed with ease using an old track which leads to a quarry carved out of its north-western side, near the summit. In the bed of a stream that trickles from the summit, alpine and southern plants grow together. Wild London pride, which has white flowers and spoon-shaped leaves, is a plant of mild, shaded habitats and is common in south-west Ireland. Here it grows at the extreme northern limit of its range with an alpine species, starry saxifrage.

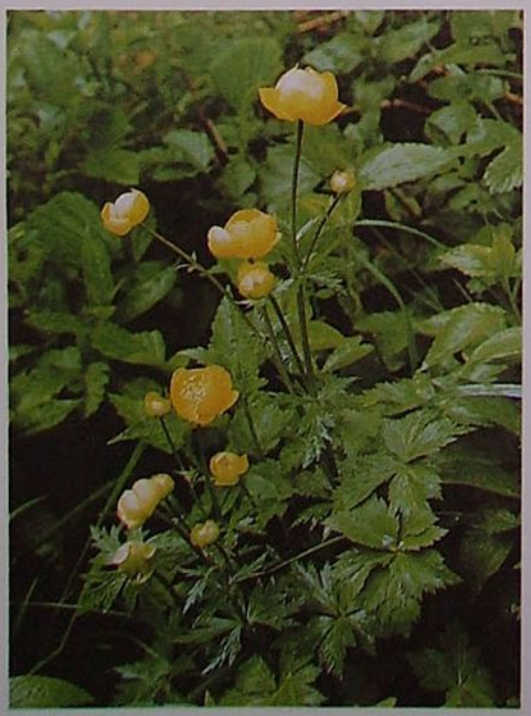
Higher up on this side of Muckish, London pride disappears, but new alpines appear. Viviparous fescue grows here–it does not produce seeds but forms miniature plantlets on the spent flowering spikes. Alpine club-moss and dwarf willow abound on the upper slopes. On the summit plateau only the most robust species thrive. The wind, constantly blowing white silica sand from the old quarry, acts like shears cutting everything to the ground. The sparse vegetation consists of stunted bilberry, a carpet of dwarf willow and hummocks of thrift, which has the most beautiful rose-pink flowers. There is also plenty of ling, a plant that dominates the

Above: Irish spurge, a highly toxic plant, is said to be responsible for the name of a valley on the western side of the Derryveagh Mountains, the Poisoned Glen. Sadly, there is no trace of this plant in the Glen today but it does grow elsewhere in Donegal, in a small river valley south-west of Malin Head.



Right: In Donegal London pride grows at the extreme northern limit of its range. This delicate plant thrives among damp rocks and in streams on the mountain slopes.

Below left: Along the shores of some Donegal loughs the beautiful yellow globe-flower is found. Its flowers are out between June and August.



Below: One American plant species that occurs in Donegal is pipewort, which grows around the edges of the peaty loughs.

surrounding moorland.

The loughs At the base of Errigal lies Lough Nacung. It is sheltered from the cold, east winds by the Derryveagh Mountains, and is surrounded by a vast expanse of blanket peat. The plants on the moorlands include ling, cotton-grass, black moor-grass, sedges and heathers. On the lough shore, and extending not more than 100m into the bogs, grows one of the Lusitanian plants, Mackay's heath: this grows only at Lough Nacung, in Connemara and in northern Spain. It is related to cross-leaved heath and hybridises with it. There are many shrubs of this hybrid, called *Erica* × *stuartii*, at Lough Nacung, and in June and July they can be spotted easily as their young shoots are brilliant yellow or orange.

The lough is fed by numerous streams, including one that emerges from a most spectacular glacial valley, the Poisoned Glen, a great U-shaped trough carved into the western side of the Derryveagh Mountains by long-gone glaciers. Its floor is a spongy peat bog, while the sides and the back of the glen are steep rock walls. The rocks are always dripping wet, and the cool crevices provide habitats for rare ferns including the endangered Killarney fern, another southern, Lusitanian, plant.

As well as southern and alpine plants, Donegal contains several of the American species found in Ireland. Pipewort and water naiad grow in the loughs of western Donegal, in places similar to those they inhabit in Galway. Blue-eyed grass is also found in the county but it is rare–a small population grows on the shore of Lough Nacung.

Three rare plants There are three species native to Donegal that are extremely rare and fully protected under Irish law. The first, globe-flower, a relative of the buttercups, grows in two places in Ireland, both in the north-west. The Donegal populations are the largest, and are located on the shores of Lough Gartan and smaller loughs in the valley of the Lenaan River. The other Irish population is on Lough Melvin in County Fermanagh.

A second plant is the common rockrose which is widespread in Britain but in Ireland is restricted to only one area of bare limestone at Ballintra in the south of Donegal. This species has large yellow flowers.

The third species, Hart's saxifrage, is found nowhere else in the world. It is named after the man who discovered it a century ago and is confined to the island of Arranmore, which lies a few kilometres off the west coast. It is a mossy saxifrage, with a rosette of tiny leaves and lovely white flowers, but differing from other mossy saxifrages in having minute glandular hairs on the leaves and flower stalks (the other species have hairs without glands).

While Donegal appears barren and windswept, it is a very interesting place for botanists. In sheltered stream beds and on the exposed mountain slopes plants of contrasting tolerances thrive. The mildness of the climate is demonstrated in the new National Park at Glenveagh, where a sheltered garden, enveloped by planted pines, is full of tender, exotic plants such as tree ferns, rhododendrons and cabbage palms. The glen is a truly wild place, surrounded by mountains except to the north. It illustrates the paradox of Donegal–bleak and inhospitable, yet mild and fertile.

Below: The extraordinary quartzite cone of Errigal, rising some 752m (2466ft) above sea level, is the highest peak in Donegal. Its slopes are covered with scree, making it difficult for plants to grow there. But the surrounding bog supports some rare species, such as Mackay's heath.

INSECT SONGSTERS AND MUSICIANS

The chirping of the grasshopper and the buzzing of the bee are both familiar insect sounds we expect to hear in the countryside. However, would you feel the same about a moth which squeaked like a mouse, or a creaking beetle? These are just two of the unexpected sounds made by insects.

Below: If you were to handle a death's-head hawk-moth it would emit an audible squeak. It also makes this noise when it is flying about, though why it does so, no one yet knows. You have to be very lucky to find this moth, however, for it is one of our rarest hawk-moths. The most likely place to see (and hear) one is around a bee hive—these moths have a fondness for honey.

Like the songs of birds, insect sounds are often associated with the establishment of territories by males competing for a mate and the business of recognition and courtship between sexes. Since these insects are communicating with each other, they must also be able to 'hear' the sounds produced by other individuals. Therefore most are to some extent sensitive to sounds; caterpillars make flinching movements in response to a loud noise because their bodies are covered with minute hairs which respond to the air movements, created by sound waves. True, specialised hearing organs, however, are mainly confined to insects that call to members of their own species.

The sounds produced by insects arise from many different mechanisms, which can be placed in one of five broad categories: rubbing one part of the body over another; tapping some part of the body against wood; vibrating special membranes; vibrating wings during flight; and, finally, expelling air through the mouth or spiracles.

Scrapers and grinders The hard outer covering of insects consists of a substance called sclerotin, and is particularly suited to producing sound-making, or stridulatory, organs. The most familiar stridulatory organs are those of the grasshopper, which produce sound in the same way as you do when you stroke your finger nail along the teeth of a comb. In the grasshopper, a row of minute evenly spaced pegs on the inner side of the thigh-joint of the large hindlegs is rubbed across prominent veins of the forewing. This causes the wing to vibrate and so produce the 'song' of the grasshopper. Each species has its own distinctive song which some naturalists can use to identify the singer.

Crickets and bush-crickets stridulate in quite a different way. At rest their forewings overlap to form a cover over the abdomen. A rib on the upper wing, bearing fine teeth, is rubbed over a ridge near the hind margin of the lower wing. This causes the wings to vibrate and produce the distinctive chirp of the cricket.

Screeching and creaking One would not expect underwater insects to be vocal yet one species of water boatman, *Micronecta poweri*, is known as the water singer for the extra-

ordinarily loud noise it produces. It does this by stroking a spiny area of its front legs over a ridge on the side of its face. As the song is confined to males it is fairly certain that it is associated with courtship. This tiny, 2mm long, bug also has small hearing organs on its abdomen.

Many of the beetles of the family Cerambycidae, known as longhorns after their long antennae, can produce a creaking sound by rubbing their thorax against their hard wing-cases. This sound is produced when the beetles are handled and appears to serve no purpose other than that of alarming or deterring predators. In the larger species, such as the musk beetle (*Aromia moschata*), poplar longhorn (*Saperda carcharias*) and *Agapanthea villosoviridescens*, the noise is quite loud.

The screech or squeak beetle is another water insect that can produce sounds. This brown and black beetle, about 1cm ($\frac{1}{2}$in) long, lives at the bottom of ponds and water-filled ditches. If dredged up in a pond net it soon announces its presence by loudly squeaking–a sound is produced by the beetle rubbing the tip of its abdomen against a row of projections on the inside of each wingcase. The sound may be a form of communication: if a screech beetle in an aquarium is approached by another while eating a scrap of food, it squeaks in protest. Water is able to carry sound waves and the tiny pressure waves created by the squeak would easily be detected by the multitude of sensory organs over the surface of the beetle.

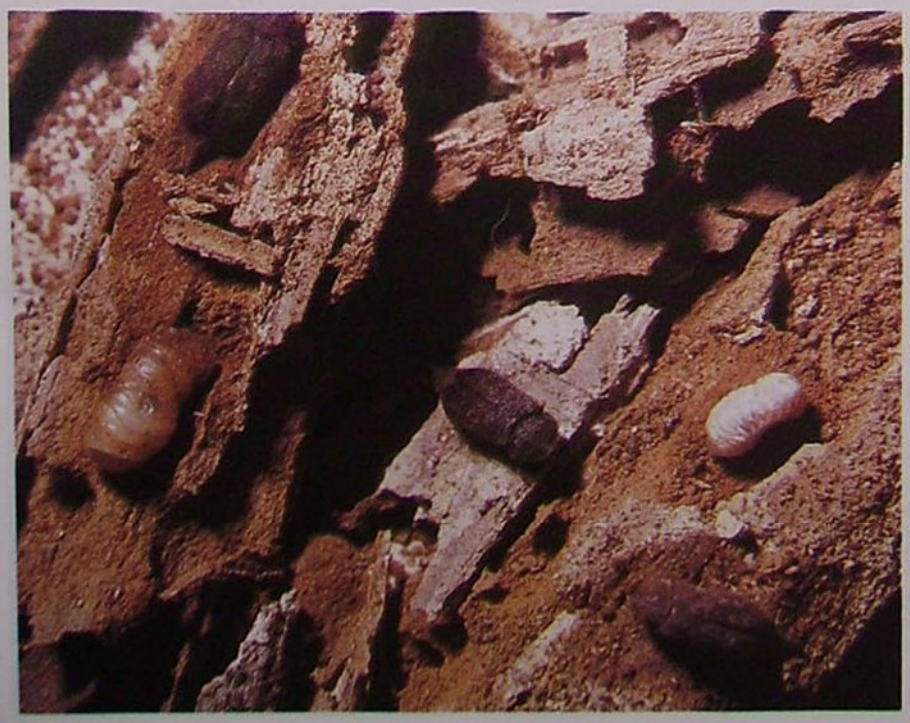
Wood tapper An unusual method of sound production is found in the death-watch beetle. This is the famous pest that lives and breeds in the timber of old houses. Its common name derives from the regular ticking sound heard at the dead of night as the adult beetle taps its head against the wooden walls of its burrow. This sound is heard mainly in spring when mating takes place and probably serves to bring together beetles in the maze of burrows which they inhabit.

Above: The only British representative of the tropical group of songsters, the cicadas, is *Cicadetta montana*, which is found in the New Forest. This insect has a quiet, high pitched song.

Below right: The carnivorous screech beetle is named because of the loud screech it makes when dredged from a pond.

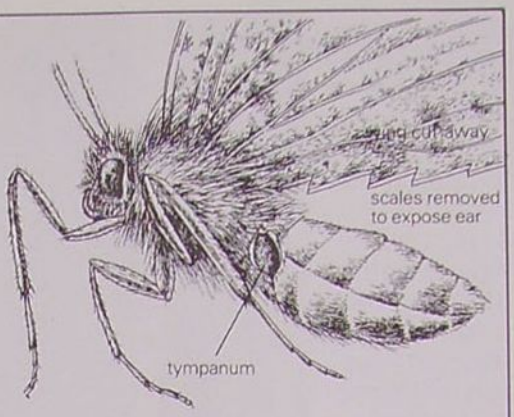
Below: In the rafters of old houses death-watch beetles communicate to each other by tapping their heads against the walls of their tunnels.

Singing cicadas One of the most characteristic sounds of the tropics is the rhythmic pulsating 'chirr' of cicadas. In Britain we have one species, *Cicadetta montana*, which is rare and confined to the New Forest. Unlike its tropical relatives, the New Forest cicada has a very quiet and high pitched song which is inaudible to many people. Its song is restricted



Ears for defence

Some insects have specialised hearing organs–ears–but cannot produce sounds of their own. For example, many moths in the families Noctuidae and Geometridae have ears in the form of sheets of cuticle, called tympana, on each side of their abdomen. These have been shown to be sensitive only to ultrasonic sounds in the same range as those used by the 'sonar' of their enemies, bats, for whom night-flying moths are an important source of food. The moth's ears give it advance warning of an approaching bat and the moth takes evasive action, sometimes by folding its wings and falling to the ground.



side view

Right: Longhorn beetles are a distinctive group because of their long antennae. If handled, many, including this adult *Agapantha villosoviridescens*, can make a loud creaking sound by rubbing the edges of their wing-cases against their thorax.

Below: Bees, such as this worker of *Bombus pratorum*, buzz loudly as their wings beat up and down, but they can also hum when resting or, as here, feeding.

to males and produced by a pair of ridged drums called tymbals, one on each side of the abdomen. The tymbal consists of a thin membrane of cuticle which can be distorted by the pull of a special type of muscle attached to its inner surface. As the muscle, called the fibrillar muscle, contracts, the tymbal is drawn inwards; when the muscle relaxes, the elasticity of the cuticle snaps the tymbal back into shape. The fibrillar muscle is capable of contracting and relaxing more than 500 times a second. The sound of the cicada is amplified by hollow spaces in its thorax and abdomen, which act as resonators. If you try to find a cicada by its singing you are likely to be disappointed, for as soon as soon as the male cicada senses your approach he will stop his song and remain safely in his leafy hideaway. The song of the cicada is thought to be a means of bringing together the sexes as both the singing males and the silent females have 'ears' near the base of their abdomen.

Far left: One of the British moths that can hear the sound of an approaching bat is the swallowtailed moth. Without such an advance warning this pale-coloured moth would be easy prey to a bat, despite the latter's poor vision.

Buzzing wings Some insect sounds are produced as a by-product of some other activity. By far the most common such sound is the humming and buzzing of flies and bees. A very familiar insect with a high pitched hum is the mosquito, which beats its wings around 500 times per second. Male mosquitoes possess elaborately branched antennae with a sensory organ at the base of each. These organs are particularly sensitive to the pitch of the note given out by a female of the male's own species when in flight. This helps him to pick her out from females of other mosquito species, and also from other males of his own species–male mosquitoes produce a slightly higher frequency hum than females.

The familiar buzzing of bees is only partly produced by wings, the basic tone of the wing beats being modified by the rapid vibration of the cuticle of the bee's thorax and possibly also by the exhalation of air through its breathing holes, or spiracles. Bees also make a high-pitched sound while not flying which can be attributed to the last two mechanisms. Newly emerged queen honey bees are able to produce a shrill piping sound

Below: Grasshoppers use their songs to attract mates and warn off competitors. This male rufous grasshopper can be seen actively singing by 'fiddling' with his back legs.

by passing air through their spiracles. This sound is used by the queen as a way of communicating with her swarm.

Squeaking moths Mammals and birds make sounds by expelling air from the lungs and passing this over elastic membranes or cords. Voices of this kind are rare among insects, but they are found in a few species. One such British example is the death's-head hawk-moth, which can squeak both when handled and when in flight. This remarkable noise is produced by the expulsion of air through a restricted opening where the proboscis enters the moth's mouth cavity, or pharynx. The moth can make this sound even before it has emerged from its pupa.

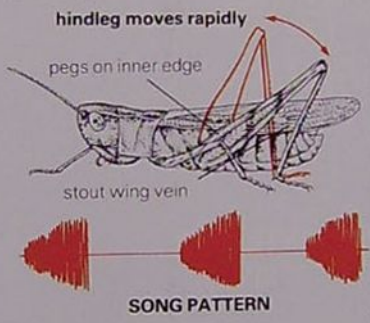
How insects produce sounds

The common feature that enables different insects to produce sounds is their hard resilient cuticle. This is an ideal material from which to make the files, spines or flexible plates necessary for sound production. Shown here are some typical sound-producing insects and the different ways in which they make their noises. The number of clicks or taps made in a second is represented diagrammatically as frequency plots.

Stridulation

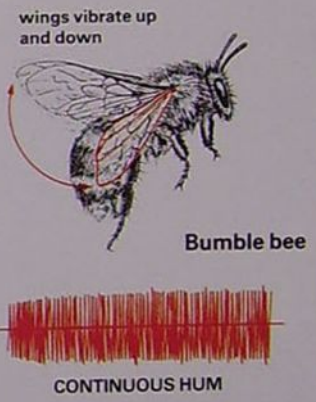
Stridulating grasshoppers (right) produce their sounds by rapidly scraping a fine row of tiny teeth on the inside of their hindleg across a stout vein on their wing edge. This produces a sound made up of repeating clicks, as shown in the frequency plot for this common field grasshopper.

Common field grasshopper
(Chorthippus brunneus)



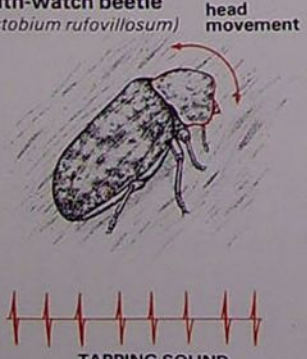
Wing vibration

Many insects produce a humming or buzzing sound as they fly. In the bumble bee (right) this sound is partly caused by the rapid vibration of its wings, but it is augmented by the movement of the cuticle on its thorax. This occurs when the muscles inside the thorax distort the cuticle as they contract, and then allow it to click back as they relax.



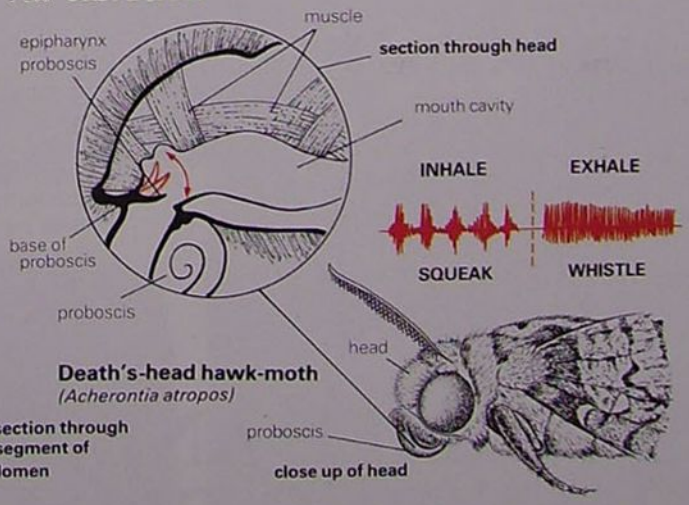
Tapping

Death-watch beetle
(Xestobium rufovillosum)



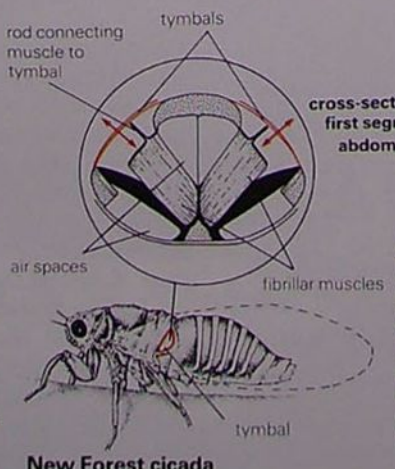
The sound produced by the death-watch beetle (left) has been described as a scaled-down pneumatic drill. This strange sound is produced by the adult beetle banging its head on the wooden beams and furniture in which it breeds, and can be heard to consist of distinct taps, produced about seven or eight times a second. It is thought to be the beetle's mating call, serving to draw together males and females.

Air vibration

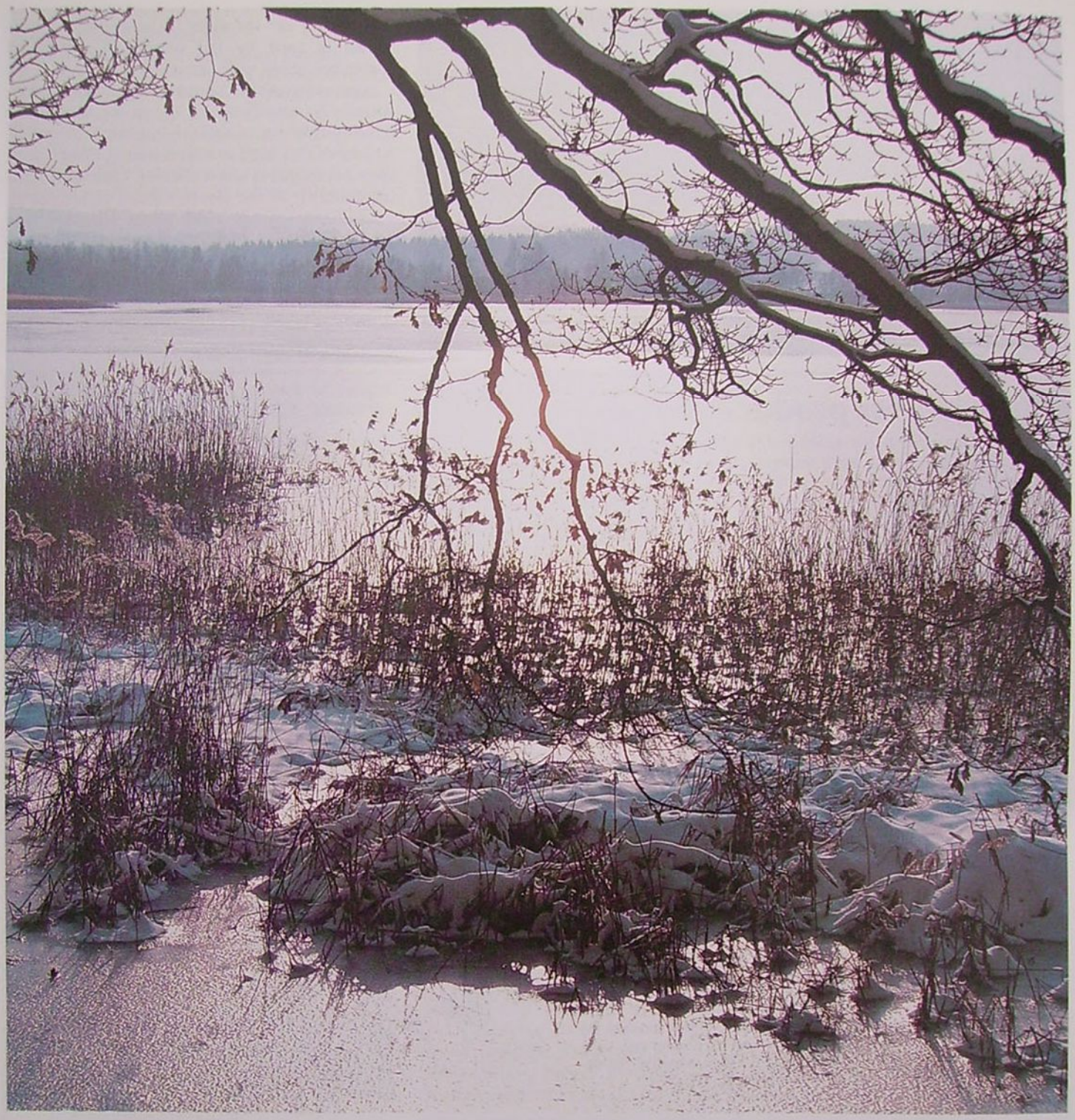


Vibrating membrane

The sound-producing mechanism of the cicada (right) is best seen as a section through the base of its abdomen. This shows how the tymbals vibrate in and out so quickly that they appear not to move at all. Each 'click' of the elastic tymbal (represented as a dash on this frequency plot) blends in with the next.



One of the most extraordinary sounds made by an insect is the noise produced by exhaling or inhaling air and passing this over a flexible flap. This is similar in many respects to the way our own voice is produced. The death's-head hawk-moth can suck air through its proboscis and cause a flap of cuticle, called the epipharynx, to vibrate rather like the reed in a clarinet. This produces a squeak when air is pulsed over the epipharynx or can produce a shrill whistle if air is rapidly forced out through the proboscis.



WILDLIFE AND OUR CHANGING CLIMATE

Our climate over the past two thousand years has been far from unchanging. Instead we have had long periods of alternately warm and cold weather, which have had an important influence on our wildlife, and we now seem to be entering another cold phase.

People have been keeping reliable weather records only for about the last 300 years. To find out what our climate was like before that we may look at indirect evidence, such as contemporary writing and human activities. More scientifically, investigations into lake-bed sediments and peat bogs reveal the plants and animals living at different times in the past. Some of these now live far to the north, or far to the south, of us, and so we can assume that the weather at that time was distinctly colder or warmer than it is now.

When the Romans invaded Britain about 2000 years ago our climate had just about recovered from a cool wet period which had lasted some 2000 years. The Romans enjoyed

warm, dry conditions–warm enough to enable them to cultivate grapes successfully at such northerly latitudes. Their departure soon after the year 400 coincided with a deterioration to cooler, wetter weather which affected the whole of Europe, especially the north.

Some centuries later the weather began to improve again and, from about 800 to 1300, there was a long period of considerable warmth. Winters were mainly wet and mild and summers were, on average, 1-2°C (1.5-3°F) warmer than they are today. Vineyards prospered to such an extent that during the warmest phase they rivalled those of France and Germany in both quality and quantity. Little is known about the effects of this long, very warm period on Europe's wildlife, but it seems highly likely that many species associated with cold conditions retreated well to the north while more southerly species advanced northwards to replace them. The literature of the time suggests that such warmth-loving birds as the hoopoe, golden oriole and quail were then familiar birds in Britain.

The Little Ice Age The beginning of the 14th century saw a deterioration in the climate. By 1350 it had declined so much that our vineyards were no longer viable: the Little Ice Age had arrived and another 500 years were to pass before it relented. This was the period when the Thames and other European rivers often froze during the severe winters, particularly during the 17th and 18th centuries, which were the coldest periods of the Little Ice Age. Yet it was not all a time of unrelieved gloom–the climate often brought hot, dry summer spells.

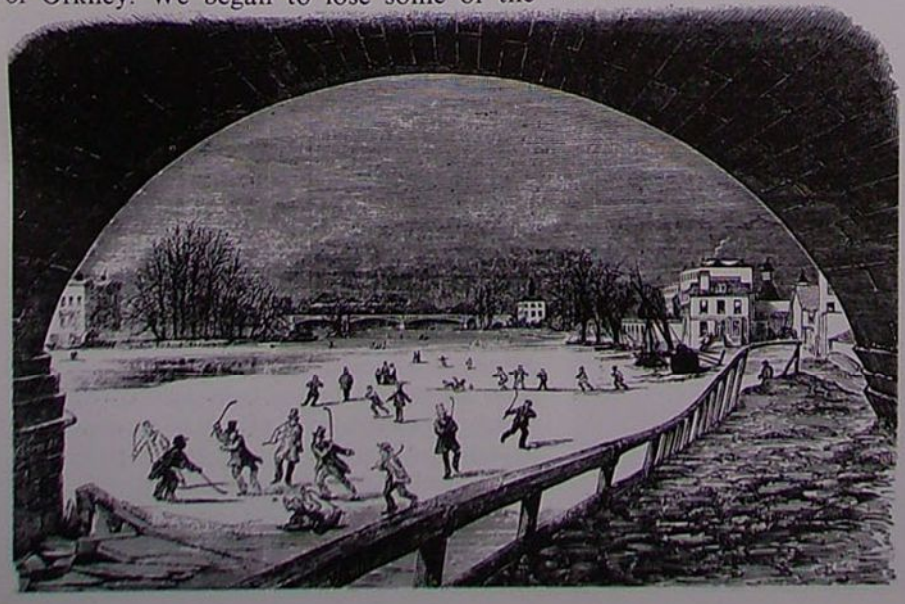
Again, there was little systematic observation that would have enabled us to deduce the effects the Little Ice Age had on our wildlife. Nevertheless, we do know that birds, seals and whales from the Arctic region ventured further south than previously. The same was true of Eskimos. Between 1682 and 1701 they were often encountered off the coast of Orkney. We began to lose some of the butterflies that had apparently been well established here during the warm weather of the Middle Ages. They included such attractive species as the purple-edged copper, scarce copper and (possibly, even) the swallowtail.

Above: The serin's fortunes during this century's climatic warming have been spectacular. Once, this finch was confined to the western Mediterranean but it has now colonized much of Europe, including Russia. In Britain, a few pairs have nested here irregularly since 1967.

Opposite page: Frensham Little Pond, Surrey, iced over in winter. The recent run of colder winters suggests that such sights may become more common in the future.

Below right: During the mild first half of this century the lizard orchid spread out from Kent to colonize other areas of south-east England. Since then, however, its range has contracted as our weather has become colder.

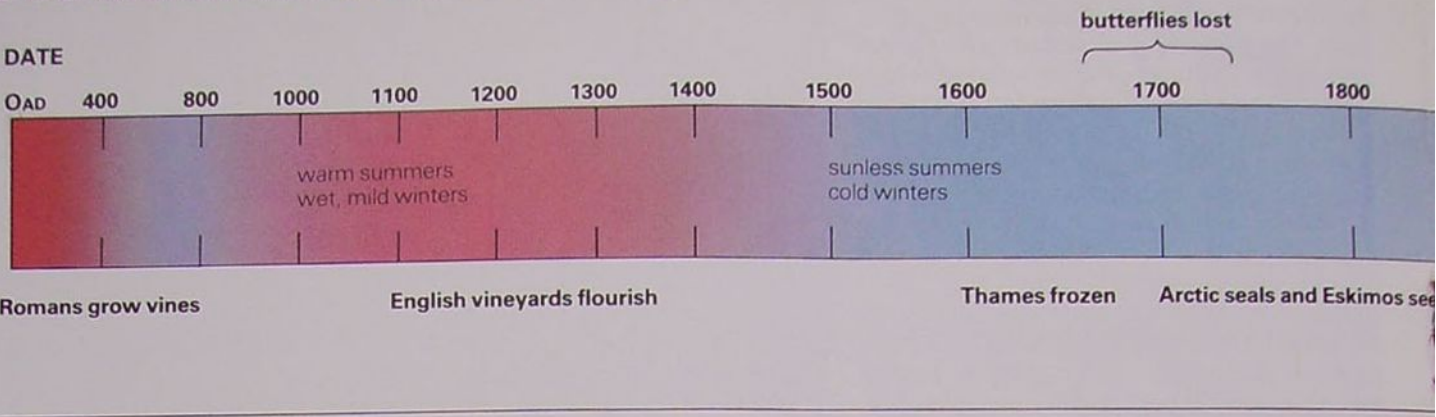
Below: The Thames frozen at Richmond in 1855, at the end of the Little Ice Age. The number of times such scenes were depicted suggests that they made a great impression on contemporary artists.



Warming up Although there were some short-lived improvements early in the 18th century the Little Ice Age did not end until the middle of the 19th century. Even then the gradual improvement, which affected the whole Northern Hemisphere, was interrupted by brief returns to cooler weather. A general warming up (which climatologists call an amelioration) began in earnest at the beginning of the 20th century.

Nobody is sure why this amelioration occurred but it resulted in Britain, and indeed the whole of north-west Europe, coming under the influence of warm, moist, westerly winds blowing from the North Atlantic. Moreover, their increased prevalence and strength, often in the shape of deep depressions, combined with a tendency to take a more northerly track, meant they carried warm air (and also warm water) far into the

Two millennia of climatic changes



Arctic. Not surprisingly the ice pack retreated northwards.

Britain's weather became increasingly maritime in character, with mild winters and wet, dull summers, particularly between 1896 and 1939. Nevertheless, when the amelioration reached its height in the 1930s and 1940s the summers were generally very warm and sunny. The 1940s also saw a run of cold winters, notably that of 1946-7, which was to signal the end of the mild weather.

Effects on wildlife The effects of this climatic warming on our wildlife have been considerable. About a dozen species of birds have either colonized Britain from the Continent or attempted to do so, and a number of others already breeding here extended their range northwards. The first group includes some spectacular successes such as Cetti's warbler, a species previously confined to the Mediterranean region but which began to expand northwards soon after 1920 and, by 1970, had colonized southern England. Even more astonishing is the spread of the collared dove, which first arrived in Britain in 1952 and now has a population of about 100,000 pairs.

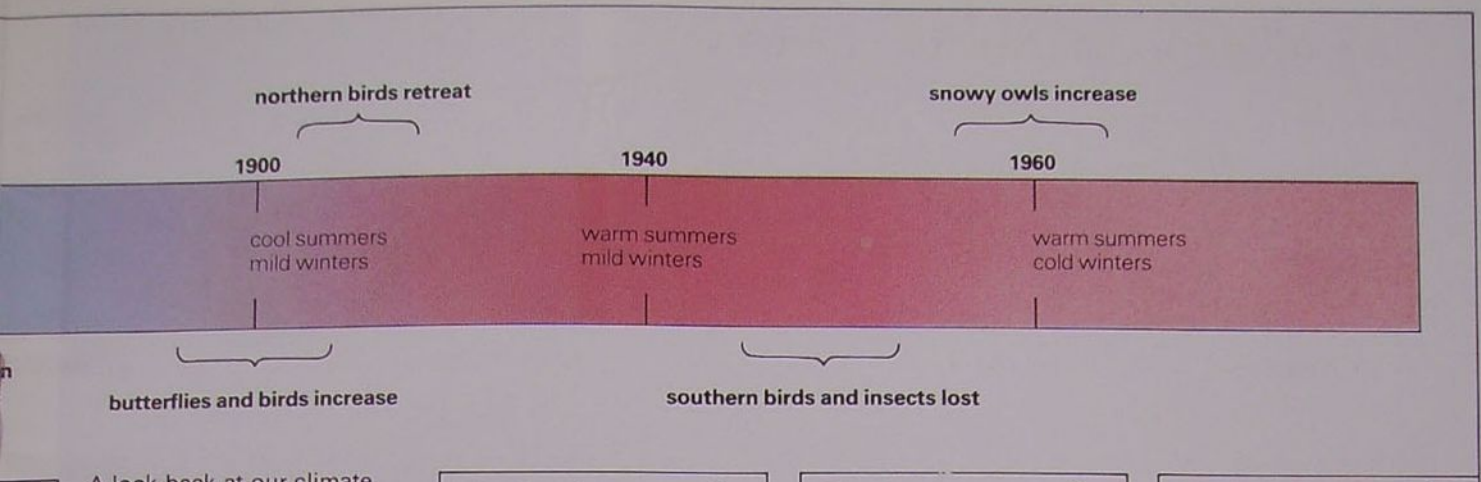
During the same period more than 40 species of moth have appeared here for the first time from Continental Europe and, as with birds, many species already here have pushed their breeding ranges northwards.

Among plants it is difficult to point to examples because they are obviously much less mobile than animals and are therefore slower to take advantage of favourable changes in climate to move into new areas. The quickest plants to respond are those with very light, wind-borne seeds like the lizard orchid, which spread between 1900 and 1940 from Kent northwards and westwards over the calcareous soils of south-east England to an astonishing extent.

The climatic trends of the first half of the present century did not suit all our species. Birds of cooler climates, such as the whimbrel and the red-necked phalarope, moved north, the whimbrel being slowly replaced by its southern counterpart, the curlew, as it did so. On the other hand the wetter, cooler summers adversely affected some summer migrants– such as wryneck and red-backed shrike– which depended upon plenty of warm sunny days to catch enough adult insects to sustain them. Both birds withdrew south-eastwards; up to 1900 they had bred regularly and quite commonly in southern Britain but had virtually ceased to do so by 1980. Likewise,

Above: The recent cooling of the climate has so far been felt more in the Arctic than in temperate regions, with the result that many Arctic species are retreating southwards. The snowy owl, for example, used to be confined to northern Scandinavia and other Arctic regions but, over the last 20 years, it has been seen more regularly further south and has attempted to colonize Shetland.

Left: A male peacock butterfly basking. Since the early part of this century this species has spread northwards and can now be found well into southern Scotland. This was due solely to an improvement in the weather since the butterfly's larval food plant, nettle, occurs throughout Britain.



A look back at our climate over the last 2000 years shows long periods of alternately warm and cold weather. This pattern is reflected in the distribution of species: the white admiral butterfly spread as summers became warmer in the 1940s; the red-backed shrike has declined because of a long-term trend towards milder summers; and the lizard orchid, which spread out with the climatic improvement of the early 20th century, has now declined again with the deterioration in our weather.

insects have retreated south-eastwards. The field cricket, for example, has almost disappeared from Britain.

Present climate The harsh winter of 1946-7 was a sign of things to come for, by 1950, the climatic amelioration was waning with a decline in average temperatures and a weakening of the atmospheric circulation. So far this has been most pronounced in the Arctic, but as it starts to bite further south one can expect to see a reversal of the processes that took place in the first half of this century. Arctic and sub-Arctic species are now moving southwards in response to the increasing cold and are reoccupying territory they last held at the end of the Little Ice Age. Thus snowy owls, redwings, buntings and purple and wood sandpipers are now attempting to colonize northern Britain.

A feature of the present weather is the occurrence of long spells of the same type of conditions, for example, the drought summer of 1976, the severe winter of 1978-9, the wet autumn of 1976 and the wet spring of 1983. These were all caused by a stationary area of high pressure. The persistence since the 1960s of such a blocking 'high' in spring over Scandinavia appears to have deflected some migrant birds away from southern Scandinavia to eastern Britain; the few breeding pairs of wrynecks in eastern Scotland and the golden orioles breeding in East Anglia are believed to have originated in this way, as is the recolonization of the Scottish Highlands by the osprey.

Below: During the Little Ice Age, which ended around the middle of the last century, Arctic seals such as this bearded seal were often seen off the coast of northern Britain. Today they are once again sighted in our waters– a sign that foretells a change in our future weather.

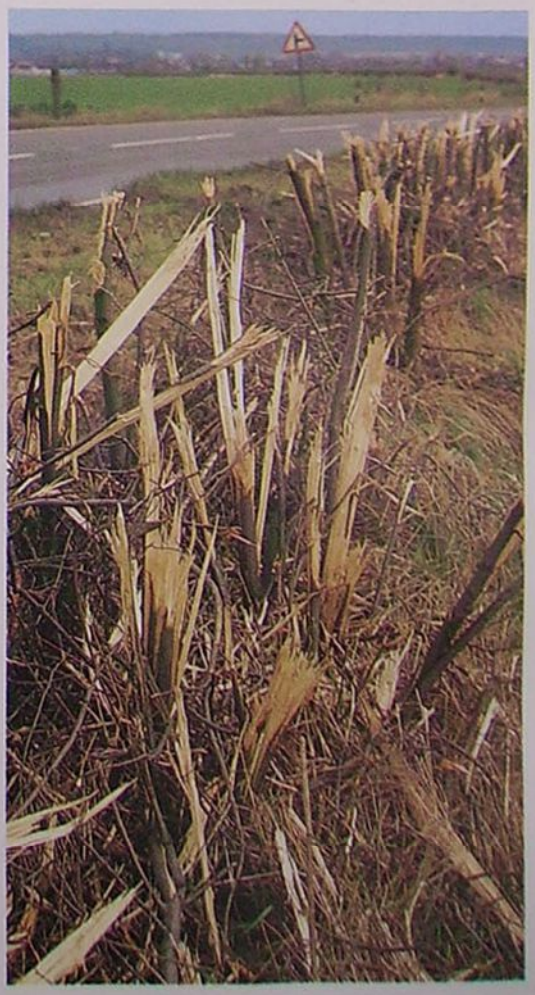
A cold future Over the next century or so it looks as if we can expect a return to the climate experienced during the 18th century. But, as Gilbert White might have assured us, that is not a cheerless prospect: we can expect cold winters more often, but also rather less Atlantic weather, and more frequent hot, dry, Continental-type summers like that of 1983.

HEDGEROWS: A CLUE TO THE PAST

Britain's hedges have developed over many hundreds of years. By examining the plants growing in them you can discover their origins–perhaps a hedge you know once formed the boundary of an Anglo-Saxon village or it may have been an Enclosure hedge.

Hedgerows are such an integral part of the countryside that it is often easy to forget that they are man-made structures. As such they must be trimmed and managed for, left to themselves, they grow tall, encroach on to the nearby ground and eventually disintegrate.

The most widespread and effective form of hedge management used to be layering, or laying, but it is a labour intensive job and, as a result, has declined in recent years. The hedge is first cleaned: the ditches may be cleared out, climbing plants cut away and the weaker branches of hedge shrubs trimmed to leave a line of sturdy upright branches, the pleachers. Each pleacher is almost, but not quite, severed by a skilled downward cut with a billhook



Above: Hedge layering is usually regarded as the traditional method of managing a hedge, although sadly it is in decline as a result of the increasing cost of labour. It is a skilled job and worth the extra work, for a layered hedge is extremely stock-proof. Nowadays hedges are usually cut with mechanical cutters such as flails. Despite the apparent damage caused (see right) the shrubs do recover, but a hedge trimmed in this way often tends to have gaps.

Above: Hedge types can differ markedly from one part of the country to another. The beech hedges of Exmoor are a characteristic feature of this part of Devon and Somerset; they are also common in the chalk downlands of southern England.

Above left: This photograph, taken from a gateway, shows a cross-section through an A-shaped hedge. Such a shape, produced by lightly trimming the hedge, provides a denser barrier than would a hedge cut with a flail.

Right: Blackthorn was a popular shrub for planting in hedges, because it grew rapidly and its prickly nature deterred cattle from breaking through.

Below: The yellow catkins of hazel make it a conspicuous hedgerow plant in spring. Its presence usually indicates that the hedge is fairly ancient.

leaving the pleacher still attached by a strip of bark. The pleacher is then bent over until horizontal and interwoven with the other pleachers down the row. Sometimes stakes are driven into the hedge in a row to secure the pleachers in place. The hedge is then left for a period of ten to fifteen years before it is again layered.

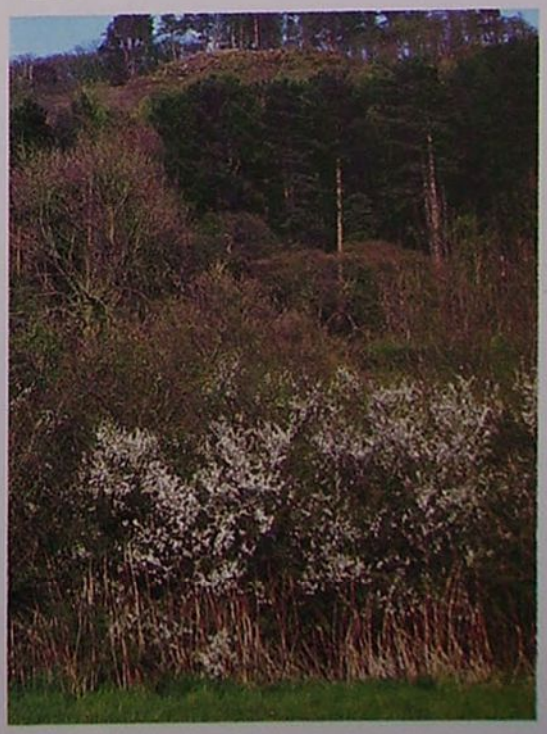
Hedge layering methods can vary slightly from one part of the country to another, and today the technique remains strong in only a few counties, mainly those in the Midlands. Nevertheless, most areas sport hedges that show signs of having been layered in the past; the thin pleachers have now developed into massive horizontal trunks.

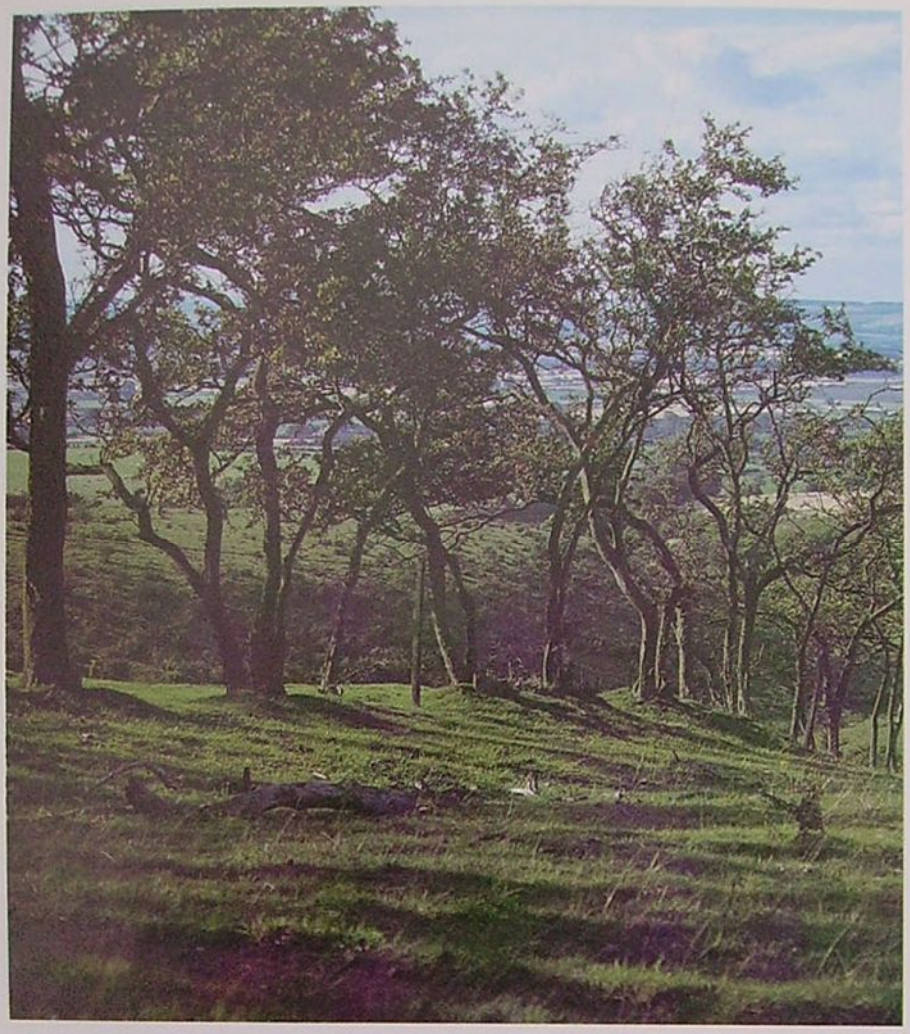
Mechanised trimming Now, in these cost-conscious times, most hedges are trimmed with mechanical cutters. Hedges cut by one such machine, the tractor flail, are easily recognised for they tend to be rectangular in cross-section and display an unsightly mess of torn branches. The wounds do heal and produce fresh green shoots, but the hedge often tends to have gaps at the bottom.

A denser barrier can be made by trimming the hedge more lightly in an A-shape cross-section. This exposes the plants at the base of the hedgerow to the sun so they do not die and leave gaps. Neither of these methods appears quite as effective as the traditional hedge layering technique, but they are less time consuming and therefore cheaper.

Enclosure hedges Many of the hedges trimmed today date from the 18th and 19th centuries when a set of Parliamentary Acts, the Enclosure Acts, were passed which, in effect, changed the face of the countryside. These brought an end to the ancient open field system and enforced the sectioning up of land into smaller, more manageable fields, about 4ha (10 acres) in size. The new fields were enclosed by planting lines of shrubs or, in the hill country, building stone walls. Hawthorn was the most popular species for planting because it grows rapidly, is prickly enough to deter stock and is quick set (living twigs can be set straight into the ground to root and grow).

Anglo-Saxon origins It appears that at least half the hedges in Britain today date back to before the Enclosure movement. Some of





Dating a hedge

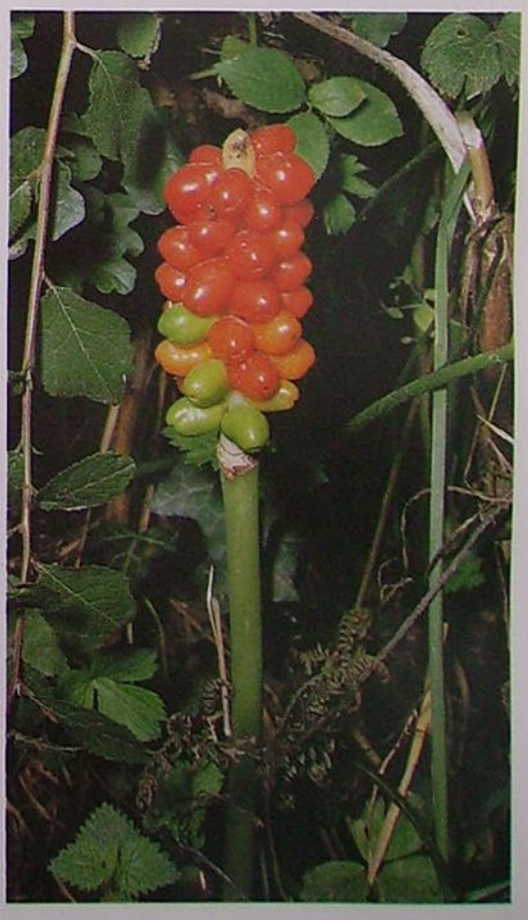
Examining local documents is the most accurate way of dating a hedge but it can be a lengthy task. A much simpler method can be carried out in the field to give you a hedge's approximate age. Mark your chosen hedge into 30-stride lengths (about 30m) and walk down each length, one side only, counting all the different woody plant species you see. (Include the trees, but all woody climbers such as brambles or wild roses should be considered as one). There is no need to know the names–you should be able to tell them apart by their leaves. Having done this calculate the average number of woody species per 30m length, multiply by 100 and you should have the average date of the edge. A hedge with ten species per length is thus likely to have been an Anglo-Saxon boundary hedge while one with only two species probably originated during the Enclosure movement in the 18th or 19th century.

these hedges are particularly ancient. The Anglo-Saxons introduced the idea of the village as we know it and marked out many, if not most, of today's parish boundaries. Natural markers such as streams, large rocks, cliffs and even large trees were used, but where the boundary crossed open ground a small strip of no-man's land was left. Over the years this would become invaded by shrubs and then trees, eventually forming a kind of hedge. Some of today's ancient hedges undoubtedly originated in this way. Such hedges may also have grown up alongside tracks across open fields.

Woodland relicts Other equally ancient hedges were originally strips of woodland, left when fields were cleared on either side. The woodland strip was then managed to become an effective barrier. A hedgerow in which you find bluebells, dog's mercury and other woodland plants is probably one of these relict woodland hedges. (Dog's mercury may also be present in a hedge which runs from an old wood, for this plant species migrates down a hedge at approximately 20m/65ft a century if the conditions are suitable.)

Some woody shrubs are also indicators of ancient hedgerows. Midland hawthorn grows only in old woods–it was never used as a hedge shrub. Consequently if you do find this tree species growing in a hedge the hedge is likely to be relict woodland. Hazel can also be a good indicator as it is often found in old mixed hedges. Be careful, though, for on light soil this does not apply. Instant dating of hedges has its pitfalls, and it does only give you the approximate age of a hedge–to the nearest hundred years–but it can be an intriguing line of investigation. It is best done in the late spring or summer when the leaves are out on the trees making the different species easier to identify–or tell apart.

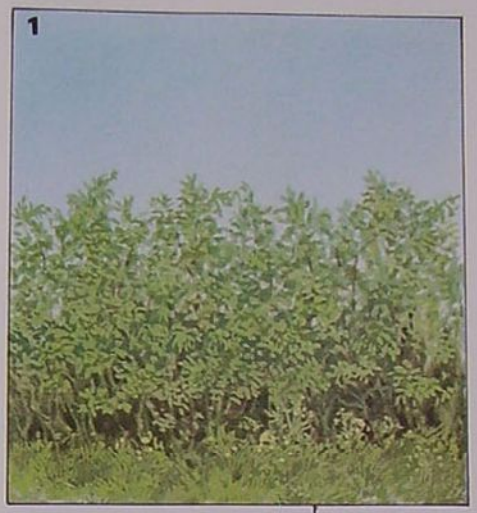
Above: A line of mature hawthorn trees marking the remnants of an old hedge. If a hedge is neglected for many years this is what eventually happens. As the trees grow the lower branches become scarcer, affording less protection for the undergrowth. The animals are thus able to reach the vegetation and feed on it. The hedge then develops gaps and stock are able to break through it causing further destruction, until finally there is little left except mature trees and a small bank of earth.

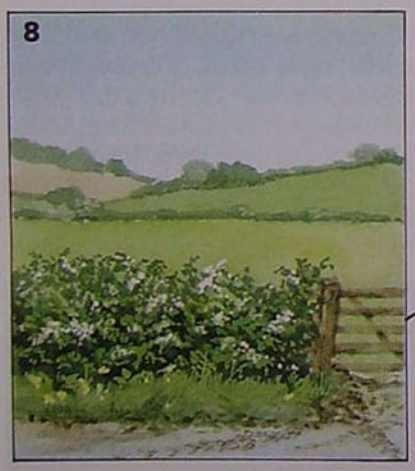


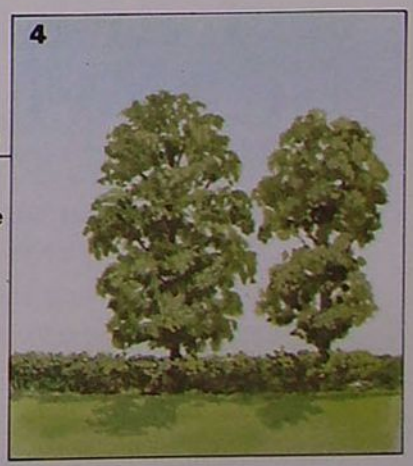
Right: Wild arum–also known as lords and ladies or cuckoo pint–is a particularly common plant of hedgerows, thriving in the damp humus-rich soil caused by the decaying vegetation of hedgerows. Its conspicuous red berries, which are extremely poisonous, ripen in mid-summer. This species is also frequently found in woodlands.

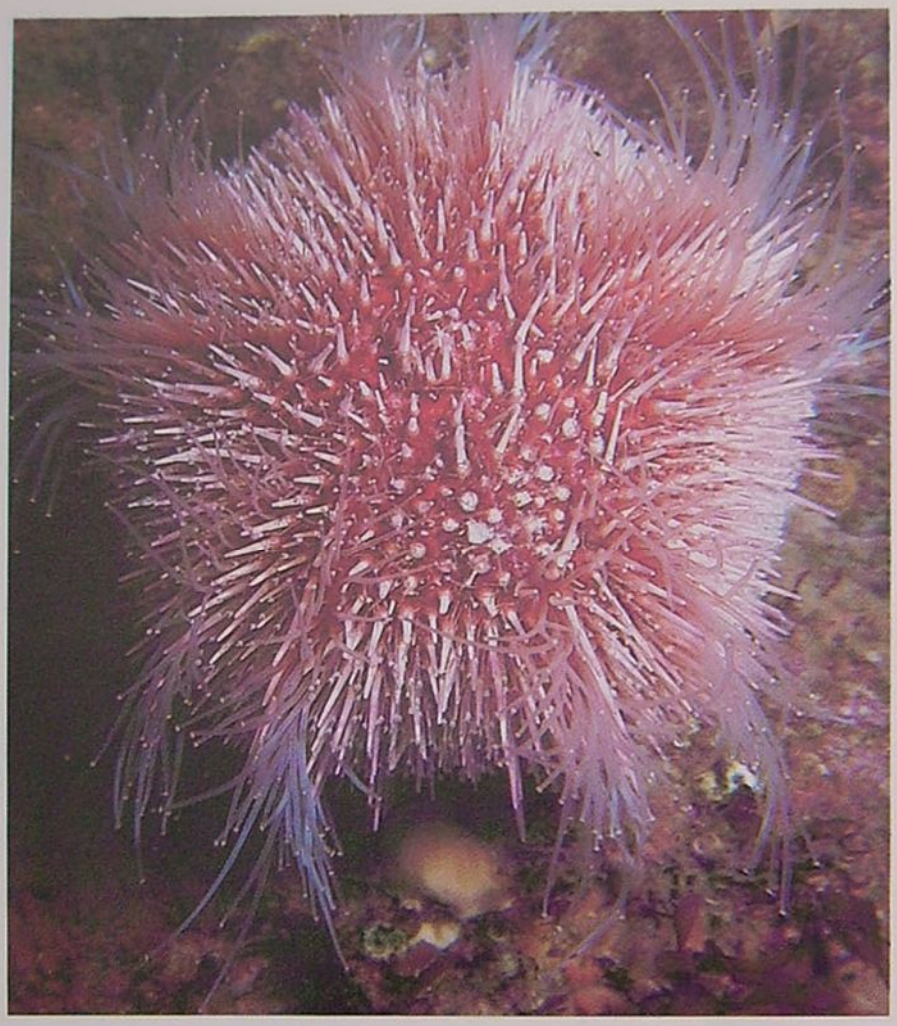
Hedgerows of Britain

Plant species growing in hedges can differ from one region to another. Some hedges reflect the soil type–beech thrives on chalky soil, hence it is used in the hedges of southern England–while others may be related to the region's economic past: damsons were planted in West Country hedges so their berries could be used as a wool dye. Below are some hedge types and a map showing where you can expect to find them. (Note that these hedges are not confined solely to the areas specified.) **1 Ash hedge** in Northumberland. **2 Holly hedge** in Staffordshire. **3 Blackthorn hedge** in Cambridgeshire. **4 Elm hedge** in East Anglia. **5 Layered hedge** in the Midlands. **6 Beech hedge** in the downlands of southern England. **7 Damson hedge** in the West Country. **8 Hawthorn hedge** in northern England. **9 Fuchsia hedge** in Ireland.









SAVING THE CREEPY CRAWLIES

Above: The edible sea-urchin (*Echinus esculens*) suffered from over-collection in the West Country. Conservation workers persuaded many divers to spare them, and populations are recovering.

Below: Our only native crayfish, *Austropotamobius pallipes*, is suffering from competition with introduced North American species.

Rare butterflies may have our sympathies, but many of our other invertebrates, apart from insects, are in need of a determined conservation effort.

We do not give very much thought to the conservation of invertebrates, those animals without backbones often referred to as creepy crawlies. After all, with slugs creating havoc in the garden, spiders in the bath and the dog suffering from worms, the reaction of most people is to wage war on these smaller forms of life. But we do not have to look far to see the important roles played by many creepy crawlies in the complex web of life; and there are many ways in which they benefit man–providing him with food and soil nutrients for his crops.

The insects are by far the biggest group of invertebrates and, with the extinction of the large blue butterfly in England in 1979, the need for their conservation is now fully appreciated. This article is concerned with the huge variety of other animals in the invertebrate world, ranging from sea anemones, worms and octopuses to lobsters, woodlice and starfishes.

Habitat destruction While animals such as bears and wolves were long ago ousted from temperate countries like Britain, most invertebrates have managed to cling on. Many can survive in extremely small ranges or have the ability to disperse to new areas on wind, in water or through the agency of man and other animals. But as the last remnants of natural habitat become increasingly threatened, the future of many of these animals is beginning to look bleak. Small ranges can be a serious disadvantage since a single event, such as the draining of a marsh or the building of a factory, can wipe out the entire population. For example, the ladybird spider (*Eresus niger*), a heathland dweller, was thought to be extinct when its last known site disappeared under a housing estate in Hampshire. Fortunately, the spider was rediscovered in 1980.

The starlet sea anemone (*Nematostella vectensis*), living in brackish marshes and lagoons, has been recorded from only seven sites on the east and south coasts of Britain. Three of the known populations have already disappeared (largely because of man's ecological destruction). The anemone probably relies on tides and storms to disperse it along the coast and with the increasing construction of sea walls this method of dispersal is no longer suitable.

Another marsh and wetland species which has become rare this century is the medicinal leech (*Hirudo medicinalis*). Numbers were heavily reduced in the last century when leeches were collected for blood-letting, which was thought to be a cure for all manner of illnesses. Populations have had little chance to recover as appropriate habitats have disappeared through drainage and modern farming.

Pollution effects Some invertebrates, such as certain species of leeches and worms, actually thrive in mild organic pollution and appear in huge numbers in sewage outfalls and other stagnant areas. However, this is usually at the expense of other less tolerant species. The long term effects of pollution on freshwater and terrestrial invertebrates is still poorly understood, but there is evidence that some are affected by acid rain and other pollutants.

Although evidence is mainly anecdotal, it appears that pollution has contributed to the disappearance of the freshwater pearl mussel (*Margaritifera margaritifera*) from several rivers in Britain, such as the River Almond in Midlothian. *Myxas glutinosa*, a snail which used to be common in marsh drains, may also be sensitive to pollution. It has disappeared from most of its former range and is now found only in the Lake District.

The effects of pollutants in the marine environment, too, are poorly understood. Fresh oil can cause heavy mortalities of invertebrates, sometimes with long term effects, but in other cases marine communities seem to be able to regenerate quite quickly.

Human exploitation Unlike vertebrates, most invertebrates can withstand considerable collecting as they generally have a high reproductive rate. Exploitation is therefore not likely to cause many extinctions unless a population is already critically depleted or the species has a highly specialised life cycle.

The freshwater pearl mussel is one such example. It has been collected since Roman times for the valuable pearls it contains. Recently, with the growing popularity of SCUBA diving (even in rivers) and improved access to remote areas, mussel populations (mainly in outlying areas of west and north Britain) have come under increasingly heavy pressure. Mussels do not mature or start reproducing until about 12 years of age, and although traditional pearl fishermen used to leave 12 to 15 year intervals between exploitation of populations, casual collectors show no such respect.

Above: The sea fan *Eunicella verrucosa* is another species prized as a souvenir, and over-collected, by sports divers.

Below: The Roman snail (*Helix pomatia*) is slow to mature and reproduce, so exploitation without careful control can easily reduce a population to below viable numbers.

Marine invertebrates generally have large populations and wide ranges as a result of their planktonic juvenile stages, which can drift for many miles on ocean currents. Exploitation of marine invertebrates for food is generally to be encouraged, provided that this is carefully managed.

What can be done? The UK Wildlife and Countryside Act lists three snails (*Myxas glutinosa*, *Catinella arenaria* and *Monacha cartusiana*) and two spiders (*Dolomedes plantarius* and *Eresus niger*) as well as a number of insects. But legislation to protect individual species can hardly help unless it also provides for controls over habitat alteration.

In 1982 the Nature Conservancy Council initiated an Invertebrate Site Register, with the objective of compiling an inventory of sites of importance for the conservation of invertebrates in terrestrial and freshwater habitats in Britain. This will ensure that invertebrates are brought into the mainstream of conservation and that measures to safeguard and maintain them are given equal weight with other biological interests. One British invertebrate which has been the object of conservation efforts, including a sponsored walk, is, of all things, a spider. In Britain the formerly widespread great raft spider (*Dolomedes plantarius*) is now found only in Redgrave and Lopham Fens Nature Reserve in Suffolk.

Above: In spring, male pied flycatchers moult into their breeding plumage: black or (as here) brown and black on the head and wings.

Below: A male smew in eclipse plumage, when it resembles the female.

HOW BIRDS MOULT

Any bird that lives to adulthood undergoes an outright transformation at least once in its lifetime: the complex process of moulting its plumage.

No bird can escape the need to moult. A down-covered nestling has to grow waterproof contour feathers–the shafted, veined feathers that form the adult bird's outer covering, including the wings and tail. A dull-coloured juvenile must develop adult breeding plumage, and adults have to replace worn feathers. For their weight, feathers are remarkably strong and durable. With regular bathing, oiling and preening, most will last a full year, but beyond this, wear and tear, or more technically abrasion, becomes progressively more serious.

A time to moult The timing of moult is influenced by several factors. For example, the act of growing new feathers is bound to place extra nutritional demands on a bird, so moult does not take place in winter, when food may become scarce. Birds scarcely moult during the breeding season either, when family commitments are considerable. Another constraint affects migrant species–since old feathers have to fall out before new ones can grow, insulation and flight are temporarily impaired, and migration over long distances with worn or missing plumage would be very hazardous.

For these reasons, the time of moulting is generally late summer or autumn. Most birds replace all their feathers only once each year, at this time of year. At the end of the breeding season many parent birds look extremely worn and untidy, and their youngsters are ready to move a step nearer to adulthood with a change of plumage. At this time food is usually plentiful: insects and ground invertebrates are numerous, seeds and berries are maturing, marine life is easily found and there is an abundance of young birds and mammals for predatory birds.

The sequence of moult For any bird,

Three moulting strategies

simultaneous loss of all feathers would be catastrophic, and a strict order of replacement is essential if near-normal flight and weather-proofing qualities are to be retained. At the other extreme, it is not possible to replace feathers only one at a time–growing at a rate of about 3-4mm per day, it would take all year to develop a set of flight feathers alone. A swan, for example, has some 25,000 contour feathers, while a smaller bird such as a swallow has about 1500.

Although there are many modifications, the majority of birds moult according to a basic sequence in which up to around 50% of feathers will be actively growing at any one time, including some nearly fully grown and others hardly started.

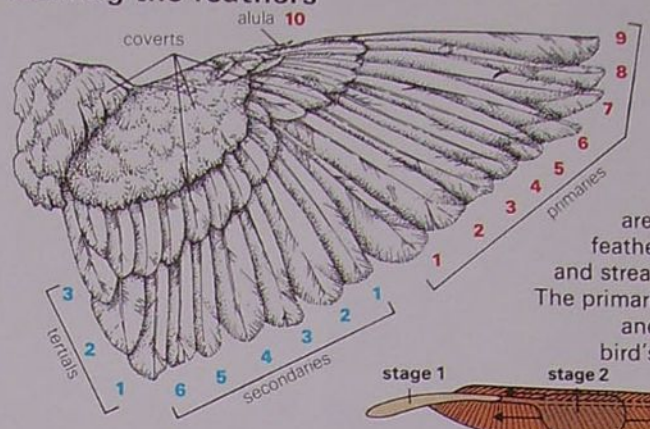
In dealing with moult, there is a conventional style in which the feathers are given numbers: primary 1 lies next to the outermost secondary (secondary 1), so that primary 10 is the one that very often takes the form of a tiny 'thumb' feather on the leading edge of the wing. Secondary 6 (most passerines have only six secondaries) is separated from the body by three more flight feathers, the tertials.

First, primary 1 falls out, leaving a tiny pit or follicle through which the replacement feather soon emerges. Initially the new feather is covered in a waxy sheath and resembles the tip of a fine knitting needle; only when it approaches about a quarter of its ultimate length does the more familiar feather vane or web emerge, rather like a small paint brush. While the first primary is still only partly regrown, the second falls out, then the third and so on in sequence. By the time the fifth or sixth primary drops, the first primary is fully grown and the first secondary falls out. Thus, from this stage onwards both primaries and secondaries are moulting.

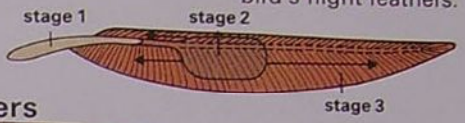
Both left and right wings moult together, and the resultant symmetrical gaps are often easy to see in gulls and crows as they pass overhead. For large birds, the whole process may take several months to complete, but

The moulting wing

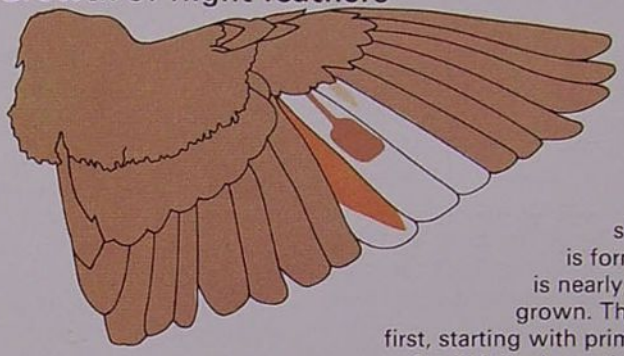
Naming the feathers



The coverts are purely contour feathers: they protect and streamline the wing. The primaries, secondaries and tertials are the bird's flight feathers.

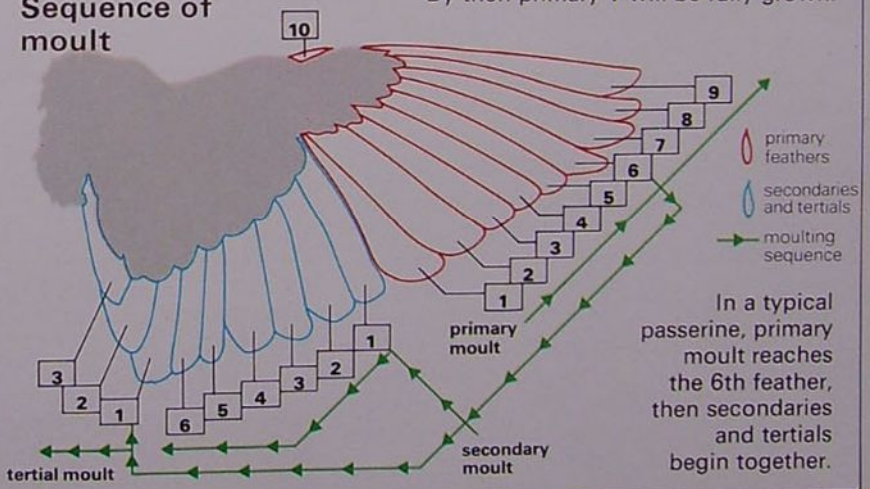


Growth of flight feathers

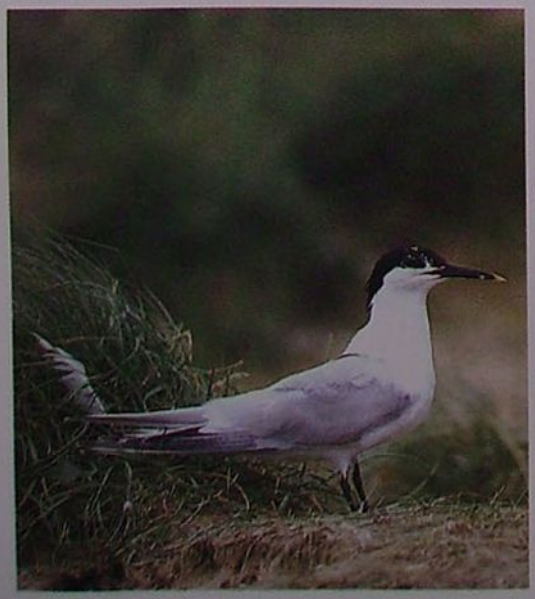


Stage **1** resembles a knitting needle tip; in stage **2** the feather is forming; in stage **3** it is nearly, but not yet fully, grown. The primaries moult first, starting with primary **1**. Secondary **1** will fall when primary **5** or **6** drops. By then primary **1** will be fully grown.

Sequence of moult



In a typical passerine, primary moult reaches the 6th feather, then secondaries and tertials begin together.



Left: After the breeding season, adult birds begin a complete moult. This Sandwich tern is moulting out the black head plumage of its breeding dress; at the same time, one of its primaries is dropping out.

Right: Young starlings in their first autumn have a complete moult, unlike most other British birds. Here a starling is moulting out of its uniformly brown juvenile plumage to become dark, glossy and speckled.

many take only two months, while some small species like the tree pipit take only 35 days.

Breeding plumage The black-headed gull and Sandwich tern are good examples of species which have a partial pre-breeding moult, in both cases to exchange white winter plumage head feathers for dark breeding colours. Since the wing feathers are not affected, this is sometimes called a body moult. Many waders, such as the grey plover and knot, grow brightly coloured body feathers in spring, and the ptarmigan changes its cryptic white, snow-like winter plumage for mottled, heather-like breeding dress.

Birds that have a pre-breeding moult therefore moult twice in a year. The breeding plumage stays in place until the season is completed, when the complete moult begins. Among the earliest small birds to begin their complete moult is the pied flycatcher: as soon as its young are fledged, the male sheds its black or brown-and-black breeding dress.

However, it should be noted that the change of colour can also be achieved by feather abrasion. Buff tips to the head feathers of chaffinches, bramblings and reed buntings overlie the breeding colours until spring when the tips have worn away.

Flightless birds Water birds like ducks, grebes, divers, geese and rails can feed and roost safely on water or among dense vegetation, and can therefore manage for a while without the power of flight. These typically drop all their primaries and secondaries simultaneously, and remain flightless for some three or four weeks until new feathers have grown. They also lose the distinction between male and female plumage, and this phase is therefore called eclipse plumage.

Some species have specific moulting grounds. For example, most of Britain's shelduck fly to estuaries on the north coast of Germany to moult; relatively few congregate at estuaries closer to hand, such as the Firth of Forth, the Humber and the Wash.

Above: Stages in the growth of a robin's plumage show the two main moults of the bird's first months of life. The chick (above left) moults out of its downy plumage into the distinctive spotted plumage of a juvenile (above right). In autumn the juvenile has a partial or body moult, attaining its red breast and resembling an adult (below). The young robin does not moult its flight feathers at this stage: these will last until its second autumn. Then, and every subsequent autumn, the bird has a complete moult. Only nine British birds have a complete moult in their first autumn: the skylark, shore and wood larks, starling, house and tree sparrows, bearded and long-tailed tits and lastly corn bunting.

Migration and moult For our summer visiting birds, the time of moulting roughly coincides with that of migration, and birds have evolved three main strategies to prevent the two from occurring simultaneously. First, if there is time, a migrant can moult before leaving its breeding area: most species that do not have to fly much further than the Equator adopt this strategy. Secondly, a few species, such as the turtle dove, regularly start their moult in Britain, suspend it while they migrate, and finish it in the winter quarters. Finally, some species delay the whole moult until they reach their winter quarters, where feeding conditions are generally good. Long-haul migrants such as garden and reed warblers fall into this category.

The willow warbler is the only British species which has two complete adult moults each year, one in autumn before migrating south, and one in winter before migrating north. This species migrates further, and may have less durable feathers, than the chiffchaff, which is almost identical in appearance, yet moults only once a year.